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**FINAL**

# **ENVIRONMENTAL STATEMENT** **FOR THE** **GEOOTHERMAL LEASING PROGRAM**

**Volume II of IV**

**Clear Lake-Geyers Known Geothermal Resource Area**

**Mono-Long Valley Known Geothermal Resource Area**

**Imperial Valley Known Geothermal Resource Area**

**Comments and Responses on the Draft Environmental Impact Statement**

**Consultation and Coordination in Development of the Proposal**

**and Draft Environmental Statement**

**Coordination in the Review of the Draft Environmental Statement**



**U.S. DEPARTMENT OF THE INTERIOR**

**1973**



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FINAL ENVIRONMENTAL STATEMENT  
FOR THE  
GEOTHERMAL LEASING PROGRAM

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Prepared in Compliance With  
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Prepared by

UNITED STATES DEPARTMENT OF THE INTERIOR

1973

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## SUMMARY

### Final Environmental Statement

Department of the Interior, Office of the Secretary

1. Administrative type of action

2. Brief description of action:

The Secretary of the Interior is charged with the implementation of the Geothermal Steam Act of 1970 (30 UCS 1001-1025(1970)) which provides for the development of federally owned geothermal resources. Section 3 of the Act defines the public lands potentially available for geothermal leasing. These include principally: (1) public, withdrawn, and acquired lands administered by the Secretary of the Interior (approximately 541 million acres in 25 States); (2) national forests and other lands administered by the Forest Service, Department of Agriculture (approximately 187 million acres in 45 States and Puerto Rico); and (3) lands containing a reservation to the United States of the geothermal resources. These lands total 638 million acres. The most promising geothermal resource areas appear to be located predominantly in the 11 western States and Alaska.

Included in this proposed action are: (1) the promulgation of leasing and operating regulations pursuant to which the program would be administered; and (2) the leasing of federally owned geothermal resources for development in three specific areas: (a) Clear Lake-Geysers; (b) Mono Lake-Long Valley; and (c) Imperial Valley, all in California.

3. Summary of environmental impact and adverse environmental effects:

Lands under consideration for geothermal leasing presently are subject to use for grazing, forestry, mining and other mineral production, fish and wildlife habitat, outdoor recreation, and watersheds.

Development of geothermal resources entails construction of access roads and well sites, drilling and testing of wells, conveyance of steam over short distances to electric power plants and by-product processing plants, construction and operation of electric power plants, by-products facilities, electrical transmission lines, and facilities for disposing of waste liquids.

Locally, land would be preempted or restricted from uses such as wildlife habitat, recreational use, grazing, etc. Terrain would be modified through construction of roads, wells, pipelines, and industrial facilities. Noise and noxious gaseous emissions could pose problems during testing and production. Possible adverse effects include land subsidence due to production of fluids and increased seismicity due to production and reinjection of fluid wastes to producing zones.

## INTRODUCTORY NOTES, VOLUME II

This volume of the Geothermal Leasing Program final impact statement contains the individual environmental statements for the leasing of federally owned geothermal resources for development in three specific areas: (a) Clear Lake-Geysers; (b) Mono Lake-Long Valley; and (c) Imperial Valley, all in California. It also includes a summary of the written comments received and departmental responses relative to the Draft Environmental Impact Statement issued in 1971; comments and responses on the Draft Environmental Impact Statement; consultation and coordination in the development of the proposal and in the preparation of the Draft Environmental Statement; and coordination in the review of the Draft Environmental Statement.

The Draft Environmental Statement for the Geothermal Leasing Program was released by the Department of the Interior on October 6, 1971. Notice of availability of the Draft Statement was published in the Federal Register, October 6, 1971. The notice also announced that public hearings were to be held in Reno, Nevada; Sacramento, California; and Portland, Oregon. The published notice announced that written comments would be received on the Draft Statement for a period of 45 days after the publication of the notice.

On May 3, 1972, supplements to the Draft Statement were issued which revised Chapter IV, Section C, Alternatives to the Proposed Action, and added Appendix G, Energy Alternatives, and Appendix H, Proposed Unit Plan Regulations. Notice of availability of the supplements was published in the Federal Register, May 3, 1972. The comment period on the original Draft Impact Statement, the supplemental draft, and all the geothermal leasing, operating and unit regulations was extended to June 19, 1972.

Proposed leasing and operating regulations to implement the Geothermal Steam Act, Public Law 91-581, December 24, 1970, were published in the Federal Register on July 23, 1971; revised and published in the Federal Register on November 29, 1972; revised and published in the Federal Register on July 23, 1973; and corrected in the Federal Register on August 8, 1973. Proposed unit plan regulations were published in the Federal Register on May 3, 1972; revised and published in the Federal Register on November 29, 1972; published in the Federal Register on July 23, 1973.

Public hearings were held in Reno, Nevada, on November 7, 1971; Sacramento, California, on November 11, 1971; and Portland, Oregon, on November 12, 1971.

Written comments received in response to the Draft Statement and the proposed regulations are included in Volume IV, Appendix I, of the Final Impact Statement. Reproductions of the written comments received in response to the proposed regulation revisions issued in 1972 and 1973 are included in Volume III, Appendix A-B and Appendix C-D, of this Final Impact Statement.

Written comments and hearings material were systematically indexed by the Department of the Interior and the indexed material was made available to the specialists involved in the revision of the proposed regulations and in the preparation of the Final Impact Statement. These materials are available for public inspection in the Office of the Geothermal Coordinator, U.S. Department of the Interior, Washington, D.C., 20240.

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## CLEAR LAKE-GEYSERS KNOWN GEOTHERMAL RESOURCE AREA

### A. DESCRIPTION OF THE PROPOSAL

The proposed action described herein is the leasing of federally owned potential geothermal resources under the provisions of the Geothermal Steam Act of 1970 and the proposed Geothermal Leasing and Operating Regulations within and adjacent to the area described as The Geysers Known Geothermal Resource Area (KGRA) and shown on Map G-1. Federal lands within The Geysers KGRA, with respect to geothermal resource leasing, fall into two categories:

- (1) "Grandfather lands" subject to conversion to geothermal leases in accordance with Section 4 of the Act and Subpart 3230 of the leasing regulations.
- (2) Lands subject to leasing only by competitive bidding under Section 4 of the Act and Subpart 3220 of the leasing regulations

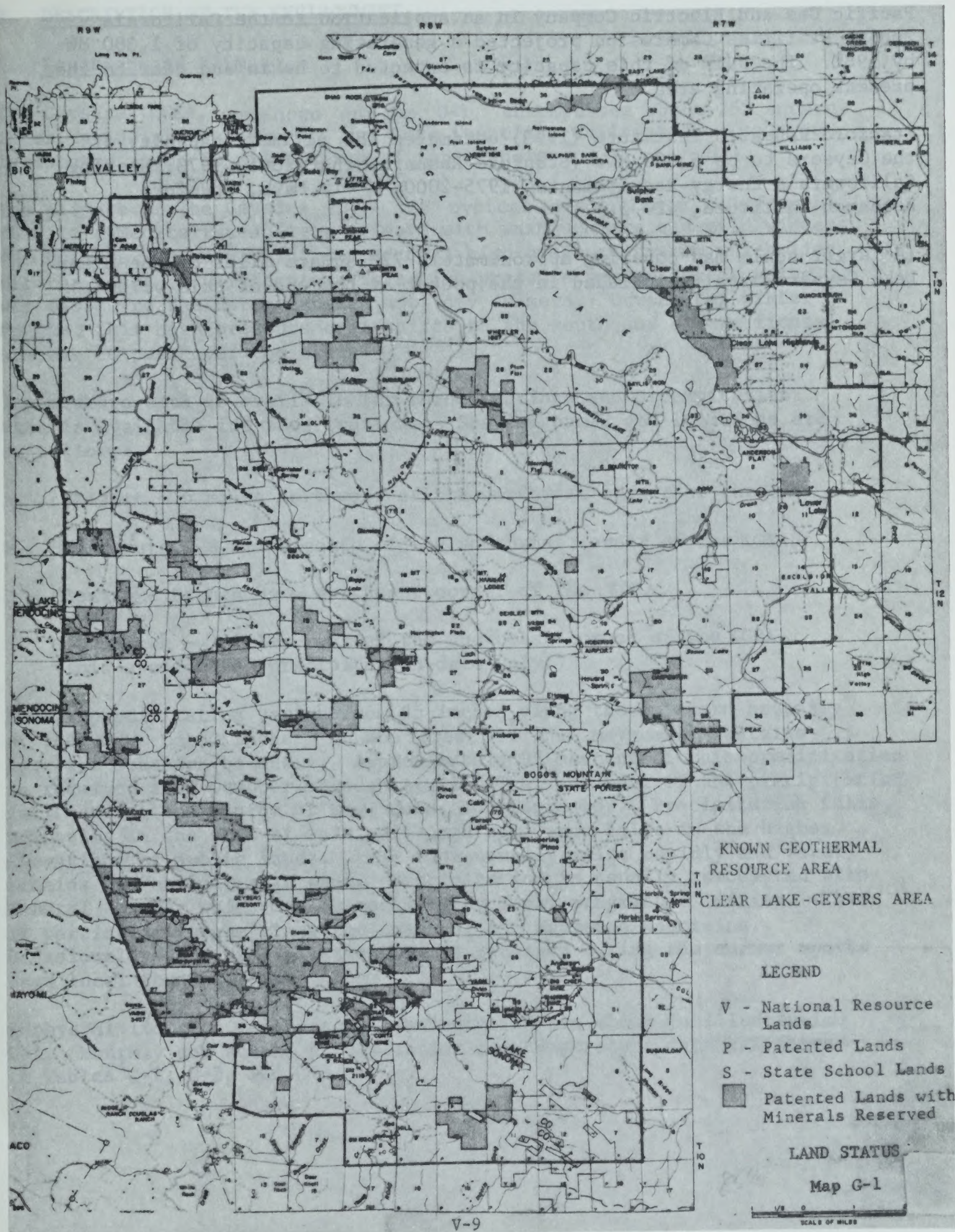
The potential leasing area within the KGRA includes 11,150 acres of national resource lands (NRL) (formerly called public domain) managed by the Bureau of Land Management and 14,000 acres of private lands on which the Federal Government reserved the mineral rights. Leases issued for the geothermal resources on the private lands may be complicated because of the division of ownership between the surface rights and the mineral rights.

Areas adjacent to The Geysers KGRA would be subject to noncompetitive leasing except where "competitive interest" as defined in Section 3200.0-5(3) of the proposed regulations results in classification of the area as a KGRA subject to competitive leasing.

All leasing actions will be subject to the preleasing procedures as set forth in Section 3200.06 of the proposed regulations.

The Geysers KGRA encompasses the only commercial geothermal power generating plant in the United States. Although exploratory drilling began in 1921, it was not until 1960 that commercial power production began. Installed generating capacity has expanded from 12.5 MW in 1960 to 298 MW in 1973. To date, all development has taken place on private lands on which the landowner holds the mineral rights.

By the end of 1973, The Geysers Steam Field is expected to be the world's largest producer of geothermal power. At present about 300 megawatts of power are on line and an additional 100 MW is expected to be added during 1973. The present production comes from wells in an area about 8 miles long and 2½ miles wide.



Pacific Gas and Electric Company in an application to the California Public Utilities Commission projected a generating capacity of 1,300 MW by 1982. The bulk of this capacity is expected to be in and near to the present operating area.

Stanford Research Institute (1973) estimates the ultimate capacity of the Geysers to be 5,000 MW. (Stanford Research Institute, 1973, Meeting California's Energy Requirements, 1975-2000; Menlo Park, Stanford Research Institute, 420 p.)

(A larger scale map covering approximately 720 square miles of the Clear Lake Geysers area is included in the pocket at the end of this volume.)

## B. DESCRIPTION OF THE ENVIRONMENT

### 1. Location and Climate

The Geysers KGRA, as shown on Map G-1, encompasses about 255 square miles, principally in Sonoma and Lake Counties, California. The area is located about 75 miles north of San Francisco.

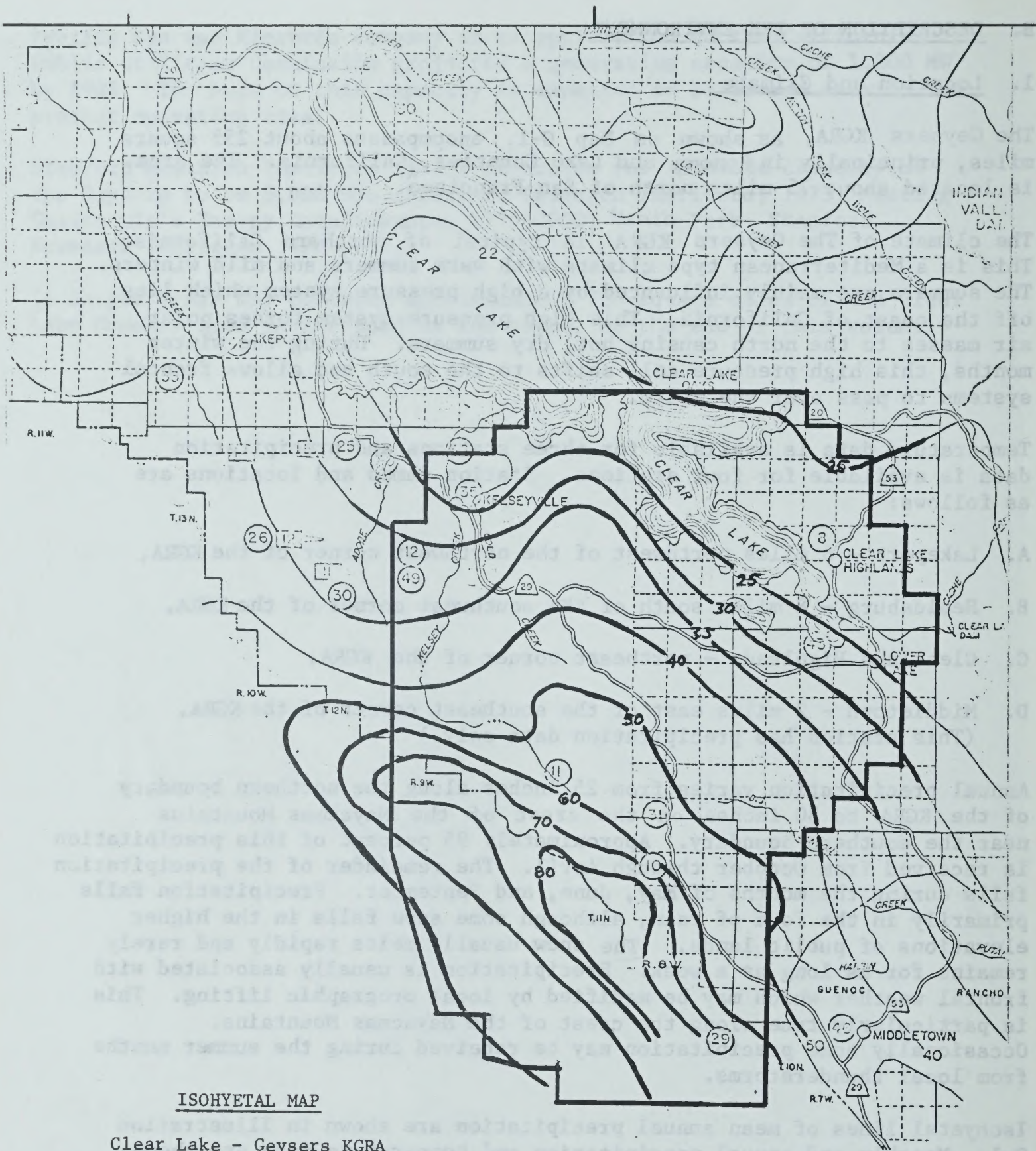
The climate of The Geysers KGRA is typical of northern California. This is a Mediterranean type climate with warm summers and mild winters. The summers are mainly influenced by a high pressure system which lies off the coast of California. This high pressure system forces polar air masses to the north causing hot, dry summers. During the winter months, this high pressure cell shifts to the south and allows frontal systems to pass over the state.

Temperature data is available for three stations and precipitation data is available for four stations. Station names and locations are as follows:

- A. Lakeport - 6 miles northwest of the northwest corner of the KGRA.
- B. Healdsburg - 8 miles south of the southwest corner of the KGRA.
- C. Clearlake Highlands - northeast corner of the KGRA.
- D. Middletown - 2 miles east of the southeast corner of the KGRA.  
(This station has precipitation data only.)

Annual precipitation varies from 25 inches along the northern boundary of the KGRA to 80 inches on the crest of the Mayacmas Mountains near the southern boundary. Approximately 95 percent of this precipitation is received from October through April. The remainder of the precipitation falls during the months of May, June, and September. Precipitation falls primarily in the form of rain, although some snow falls in the higher elevations of public lands. The snow usually melts rapidly and rarely remains for as long as a week. Precipitation is usually associated with frontal weather which may be modified by local orographic lifting. This is particularly true along the crest of the Mayacmas Mountains. Occasionally some precipitation may be received during the summer months from local thunderstorms.

Isohyetal lines of mean annual precipitation are shown in Illustration G-1. Monthly and annual precipitation and temperature data are shown in Tables G-1, G-2, and G-3.



# ISOHYETAL MAP

Clear Lake - Geysers KGRA

## LEGEND

- ~ Lines of Mean Annual Precipitation
- KGRA Boundary

Clearlake Highlands, Healdsburg, and Lakeport stations, based on data from 1966 through 1972, are shown in Table G-1

Table G-1 - Average Precipitation (in inches)

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Lakeport	9.10	3.64	2.93	1.58	.35	.41	.00	.30	.21	1.42	4.50	7.46	31.91
Healdsburg	13.04	5.30	3.83	2.46	.14	.39	.00	.14	.16	2.05	6.66	10.48	44.63
Clearlake Highlands	6.51	3.15	2.23	1.23	.38	.32	.00	.13	.18	.99	3.87	5.80	24.59
Middletown	16.73	6.00	3.83	2.84	.19	.43	.00	.25	.20	2.36	6.22	11.40	50.45

Data for the seven year period shows that temperatures range from a high of 116° F to a low of 9° F. The average annual temperature of the three stations is approximately 58° F. July and August are the hottest months and December and January are the coldest. The average monthly and annual temperatures are shown in Table G-2 based on data from 1966 through 1972.

Table G-2 - Average Temperatures (in degrees Fahrenheit)

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Lakeport	42.6°	46.2°	49.6°	52.1°	61.8°	68.9°	75.7°	74.8°	68.5°	57.6°	49.2°	41.5°	57.4°
Healdsburg	48.0°	52.0°	55.3°	57.4°	64.0°	68.5°	71.6°	72.2°	70.5°	63.2°	55.2°	47.5°	60.5°
Clearlake Highlands	41.7°	45.0°	48.2°	51.3°	61.0°	67.8°	73.9°	73.6°	67.0°	56.9°	49.2°	41.3°	56.4°

Table G-3 shows the annual high and low temperature, average annual temperature, and continuous frost-free days.

Table G-3 - Temperatures  
Lakeport

	1966	1967	1968	1969	1970	1971	1972
High-Date	108°-8/7	107°-8/17	108°-7/05	107°-7/20	107°-8/10	112°-8/11	112°-7/13
Low-Date	21°-12/27	20°-12/20	18°-12/21	21°-1/31	21°-1/03	21°-2/26	9°-12/9
Av. Ann. Temp.	57.8°	57.1°	57.6°	57.7°	58.3°	56.4°	56.9°
Cont. Frost Free Days	176	194	205	206	167	175	182

Table G-3 (cont)

Temperatures  
Healdsburg

	1966	1967	1968	1969	1970	1971	1972
High-Date	108°-9/29	105°-8/14	108°-8/29	108°-8/03	108°-7/03	114°-9/13	116°-7/13
Low-Date	28°-1/21	26°-12/15	45°-12/21	28°-1/29	27°-1/04	28°-1/04	19°-12/9
Av. Ann. Temp.	60.7°	60.2°	61.0°	60.5°	61.0°	59.9°	59.9°
Cont.Frost Free Days	298	272	305	250	324	235	307

Temperatures  
Clearlake Highlands

	1966	1967	1968	1969	1970	1971	1972
High-Date	106°-8/08	108°-8/16	105°-9/11	107°-8/03	105°-8/12	110°-8/11	113°-7/16
Low-Date	16°-1/21	18°-1/06	15°-12/21	19°-12/1	16°-1/03	17°-1/03	9°-12/11
Av. Ann. Temp.	56.2°	56.7°	56.3°	56.8°	57.0°	55.4°	56.5°
Cont.Frost Free Days	162	156	130	172	167	163	181

Continuous frost free days for the three stations vary from 130 days to 324 days. The seven year average for the three stations is as follows:

A. Lakeport	186 days
B. Healdsburg	284 days
C. Clearlake Highlands	161 days
<u>AVERAGE</u>	210 days

These stations are at lower elevations than the national resource lands (N.R.L.). Therefore, growing seasons would be shorter on the N.R.L. No data is available for the N.R.L.

Winds in the winter are associated with frontal systems and are moderate to strong from the southwest. During the summer, winds generally are from the northwest. There are occasional periods of gusty, strong winds. There are no known recurrent wind patterns peculiar to this area.

## 2. Topography

The relief of The Geysers KGRA is flat to rolling (Photo G-1) around Clear Lake, located in the northern part of the area. To the south of Clear Lake, the terrain becomes more mountainous. The Mayacmas Mountains trend northwest-southeast through the southern half of the KGRA. The roughest terrain lies along the southern boundary of the KGRA.

The southeastern one-third of Big Valley forms the northwestern corner of the area. The mouth of this large, flat valley lies along the southern shore of Clear Lake.

Elevations range from 1,200 feet above mean sea level near Anderson Springs to 4,722 feet on Cobb Mountain in the south central portion of the KGRA. The average elevation of the public lands in the KGRA is 3,000 feet.

Mt. Konocti is the most prominent point in the area. It rises from approximately 1,300 feet along the south shore of Clear Lake to nearly 4,300 feet.

The flat to rolling lands bordering Clear Lake have slopes ranging from 10 to 20 percent. The hills in the central part of the KGRA are well rounded with the upper two-thirds of the slopes averaging 30 to 40 percent. The lower two-thirds of the slopes steepen to 50 percent as they drop into the drainage bottom. In the southern part of the KGRA, the lower two-thirds of the slopes steepen to 50 to 60 percent. Slopes of 80 percent are fairly common along Big Sulphur Creek (Photo G-2).

Drainage within the KGRA flows in several directions. The area west of the divide created by the Mayacmas Mountains is drained by Big Sulphur Creek, which flows west-northwest into the Russian River. The east side of the divide drains southeast via Putah Creek into Lake Berryessa and north via Kelsey Creek into Clear Lake.

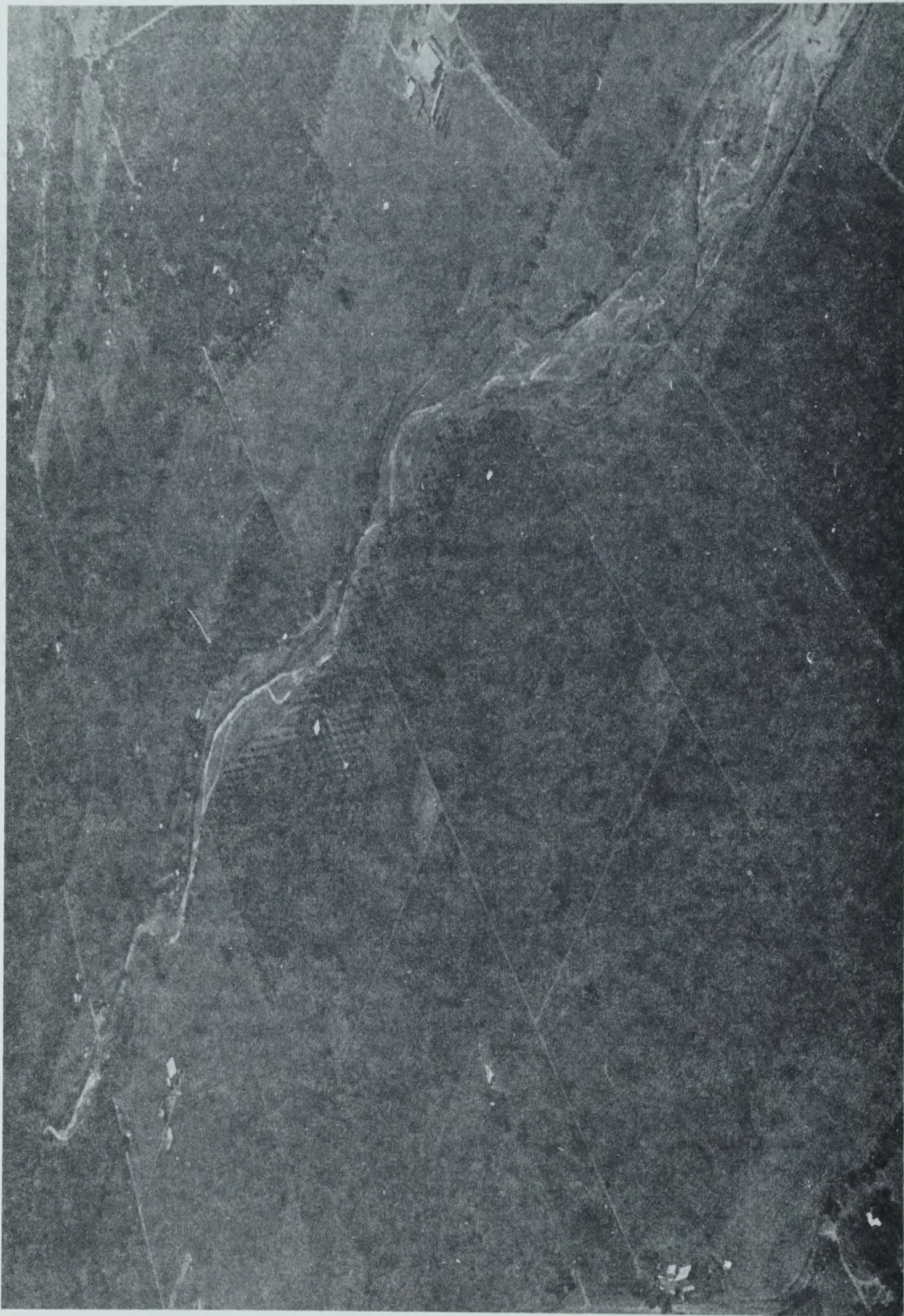


Photo G-1 - Terrain adjacent to Clear Lake is flat and suitable for agriculture

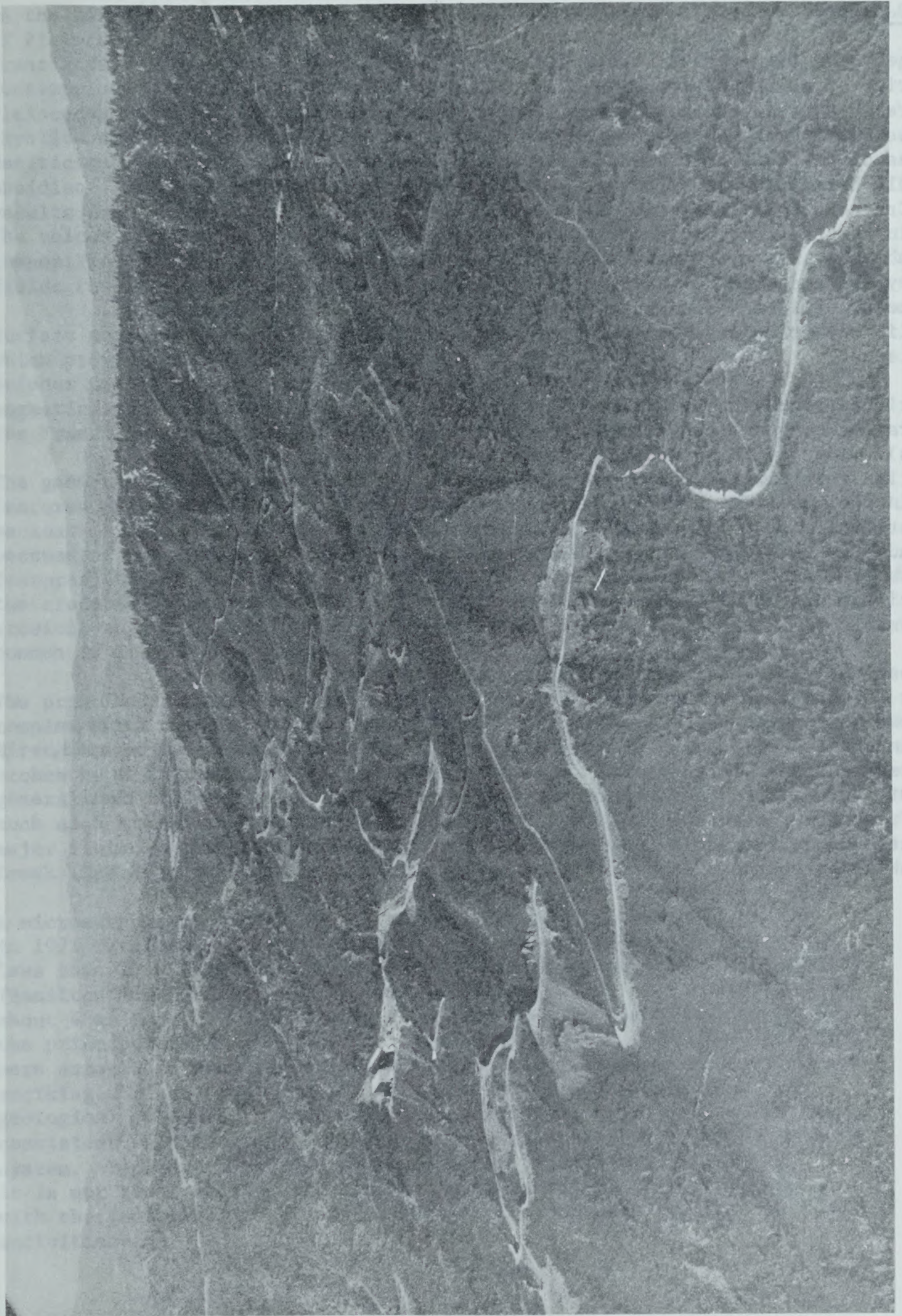


Photo G-2 - Slopes of Big Sulphur Creek in the foreground and Clear Lake in Background

### 3. Geology

The geologic framework in The Geysers KGRA is characterized by a series of northwest-trending fault zones (the downthrown sides generally on the southwest), involving a rock sequence of late Jurassic and Cretaceous age, the Franciscan Series. Within this series of tilted and rotated fault blocks lie the Mayacmas Mountains, broadly homoclinal in structure. The Great Valley Sequence, Jurassic and Cretaceous marine sedimentary rocks of miogeosynclinal origin, are in thrust fault contact with the eugeosynclinal Franciscan assemblage. The contrasting depositional environment of the Great Valley Sequence and the Franciscan, indicate largescale tectonic movement. Pliocene sediments of the Merced formation unconformably overlie the Franciscan rocks in the southwest portion of the Mayacmas Mountains.

Franciscan rocks exposed in The Geysers KGRA are characterized by graywacke, shale chert, and greenstones (altered mafic volcanic rocks). Most of the widespread greenstones are tuffs, pillows, or breccias resulting from submarine eruptions, but some massive units are intrusives. The Franciscan Series is structurally complicated by thrust-faulting, folding, and quasisplastic deformation, and beds are intruded by ultramafic masses and associated serpentine. Mercury mineralization (cinnabar) occurs in fractures and seams in brecciated Franciscan graywackes, shales, and cherts, and in the serpentized ultramafic.

The base of the Franciscan Series has not been recognized. No older formations have been brought into view, despite the many tectonic displacements within the Franciscan. The distribution of volcanic rocks, of cinnabar, the location of a major gravity "low" and areas of carbonated, borated, and ammoniated ground waters, suggest that molten material is a heat source underlying the region. Some geologists have surmised that the Franciscan assemblage was deposited upon a thin oceanic crust or directly upon the mantle. A postulated near-surface magma chamber is probably the source of the Pleistocene volcanic activity in the area.

In the northern part of the Geysers KGRA near Clear Lake, a series of Pleistocene volcanics lie unconformably on the eroded surface of Franciscan rocks or on the Great Valley Sequence rocks and may be contemporaneous with the upper most cache formation of Pliocene or Pleistocene age. Rock types include andesite (Boggs Mountain), rhyolite and rhyolite tuff (Cobb Mountain), dacitic flows (Mt. Konocti), dacitic and andesitic flows (Mt. Hannah and Seigler Mountain), and obsidian (area between Seigler Mountain and Mt. Konocti). Clear Lake results from the outlet being dammed by one of these volcanic flows. The volcanic rocks in the area are greatly diversified, both in composition, and in types of occurrence, ranging from formless volcanic fields to tableland flows, obsidian domes, and young cinder cones.

Surface geothermal activity, resulting from the subsurface heat source which provided material for the volcanic flows, is evident at Big Sulphur Creek, Anderson Springs, and Castle Rock. Heat from the magmatic source near the surface is transferred by conduction through the Franciscan country rock which has very slight permeability.

The geomorphic environment is characterized by a variety of earthflow features and slump blocks. The Franciscan Series is highly unstable because of original slump structures formed during deposition and because of the innumerable faults and shear zones. These weak structural features and the highly altered rocks within the Franciscan Series provided the erodibility and the instability necessary for landsliding, streambank erosion, and soil creep and account for the landslide debris that is common in The Geysers KGRA.

The principal faults within the Geysers KGRA are associated with the complex horst forming the Mayacmas Mountains that trends in a northwestward direction across the southwestern half of the KGRA. The horst is broken by a system of faults that parallel its long axis. These faults generally dip steeply to the southwest with dip-slip displacements of as much as 5 km. The fumarolic activity at The Geysers is associated with major fault in this system that strikes northwest along Big Sulfur Creek (Hamilton and Muffler, 1972).

A microearthquake survey run at the Geysers for a three-week period in 1971 revealed a cluster of small earthquakes (magnitude generally less than 1) within about 10 km of the existing geothermal development. (Hamilton and Muffler, 1972). Most of these earthquakes defined a zone about 4 km long, 1 km wide, and 4 km deep that corresponded closely with the principal fault. Fault plane solutions revealed that most earthquakes were associated with right lateral strike-slip motion along a north-south striking surface. This motion does not readily correlate with the geological evidence for dip-slip displacement on local faults, but it is consistent with the regional deformation associated with the San Andreas system. Because the survey was made after production was underway, it is not clear whether the microearthquakes are naturally associated with the geothermal reservoir or whether they are the result of production activities.

Three earthquakes of magnitude greater than 4 are reported to have occurred in the immediate vicinity of the Geysers KGRA between 1934 and 1961.

Two of these magnitudes 4.6 and 4.2 occurred about 7 km southwest of Kelseyville in 1955; the other with a magnitude 4.4 occurred about 10 km east of Lakeport in 1964. (California Department of Water Resources, 1964).

Two faults (the Healdsburg fault and an un-named fault in Alexander Valley) with evidence for recent surface displacement pass within 15 to 20 km southwest of the Geysers KGRA. Both faults parallel the northwest-southwest trend of the San Andreas fault and show recent right lateral displacement. One of these faults (the Healdsburg fault) was responsible for the damaging magnitude 5.6 and 5.7 earthquakes in Santa Rosa about 30 km south of the Geysers in 1969. The main trace of the San Andreas fault passes about 45 km southwest of the Geysers KGRA.

An adequate seismograph network does not presently exist in the Geysers KGRA. The U. S. Geological Survey plans to install eight new seismograph stations between Santa Rosa and Cape Mendocino in 1973 as part of its earthquake program. This network will improve the regional coverage, but additional local stations will be required to monitor microearthquake activity associated with continued development of the Geysers KGRA.

#### 4. Geothermal Exploration and Production

A major steam reservoir occurring in highly fractured Franciscan graywacke at depths of 2,000 to 9,000 feet or more has been established by drilling in an area at least eight miles long and two and one-half miles wide; but geologic evidence of a deep-seated primary heat source extends well beyond the present production at Big Sulphur Creek northward at least to Clear Lake.

Although steam vents and hot springs were discovered at the Geysers as early as 1847, it was not until 1921 that the first geothermal well was drilled along Big Sulphur Creek. By 1925, a total of eight wells had been drilled. The deepest penetration of these early wells was 640 feet; however, no utilization of this power source was made due to economic factors.

Interest in geothermal power generation during the 1950's prompted active leasing in the Geysers area north of Big Sulphur Creek. A total of 11 wells was drilled from 1955 through 1959, the deepest of which was 1,404 feet; and in June 1960, a 12.5 MW generating plant utilizing 250,000 pounds of steam per hour from four wells was operational. In addition, several wells were drilled in the vicinity of Clear Lake, several townships to the north. These wells produced thermal fluids and extended the area of Geothermal interest.

A total of about 100 wells producing dry steam have been drilled in the Geysers area, all on non-federal lands. Typical chemical analysis of steam condensate from three production wells is shown in Table G-4. Average well production is about 100,000 pounds per hour with a maximum of 360,000 pounds per hour from a depth of at least 7,000 feet. The world's deepest steam well has recently been completed in the Geysers field at a depth of 9,029 feet. At least five companies have drilled successful wells along a 7-mile zone following Big Sulphur Creek; three of the companies act jointly to sell steam to Pacific Gas and Electric Company. About 192 MW of electrical generating capacity were installed by early 1972. Present (1973) generating capacity is 298MW. By the end of 1975, the generating capacity is expected to be over 600 MW.

Table G-4. Composition (in ppm by weight) of steam condensate  
from typical wells in The Geysers field

Constituent	Well		
	Thermal #7	DX State 3395-1	Sulfur Bank 14
Silica (field)	0.50	0.20	0.50
Calcium	0.20	0.02	0.16
Magnesium	0.06	0.01	0.04
Strontium	0.10	0.05	0.10
Sodium	0.12	0.10	0.12
Potassium	0.10	0.10	0.10
Lithium	0.002	0.003	0.003
Ammonium	236.00	84.00	354.00
Bicarbonate	775.00	267.00	1153.00
Carbonate	0.06		1.05
Sulfate	7.10	24.00	11.00
Chloride	20 <sup>+3</sup>	1.6 <sup>+1</sup>	17 <sup>+2</sup>
Fluoride	0.10	0.10	0.10
Boron	0.01	5.00	0.02
pH (Field)	6.21	5.32	6.03
Specific Conduc- tance (micromhos at 25°C.)	1430.00	546.00	2090.00
Date Collected	10/28/70	10.29/70	10/28/70

Analyst: I. Barnes, U.S. Geological Survey

The area of the steam reservoir is known to be greater than 10 square miles in The Geysers field, and may be as large as 20 square miles. Previous estimates of reservoir capacity all have proven to be overly conservative and this estimate may also be conservative. Wells are spaced at one per 40 acres, without harmful interference. It has been suggested that a spacing of one well per 20 acres may be acceptable and effective in increasing steam production. However, a denser well spacing could be uneconomical and might be harmful to systematic development of the field without adding appreciably to steam recovery. Extensive areas around the known geothermal field are under lease. Three areas at distances of 20 miles or more from The Geysers have been explored by drilling. Although not commercially productive of steam, each exploratory well has encountered large volumes of hot fluids, suggesting that a sizable area may warrant further exploration.

The geologic conditions that normally cause subsidence are not present at The Geysers, and to date subsidence has not been detected. However, it might occur and in order to detect it, the Geological Survey has begun to monitor possible ground movement in The Geysers geothermal area using three types of control surveys.

- (1) A regional network of roughly a dozen bench marks on mountain peaks and ridgetops, extending 10 to 20 miles out from The Geysers; the horizontal distance between these bench marks to be precisely surveyed annually by geodimeter.

- (2) A local network of several dozen bench marks throughout the geothermal production area, precisely tied twice a year to reference bench marks of the regional network by electronic distance meter.

- (3) A line of levels to first-order accuracy by the National Geodetic Survey, establishing accurate elevations for reference bench marks in The Geysers area.

The regional network, (1) above, was established by the Geological Survey Office of Crustal Studies during October 1972. The local network (2), from which both horizontal and vertical changes will be monitored was established early in 1973. The level network (3), looped through the production area and tied to existing second and third-order level lines outside the production area was scheduled for leveling in 1973.

Precise surveys by the Pacific Gas and Electric Company have been run throughout the producing area. Where pertinent, these are being incorporated into the monitoring control network.

In order to evaluate the effects of steam production, extensive monitoring of seismic activity will be required. To date such monitoring has been limited to short-period research programs. During a three-week period from March 16 to April 7, 1971, the Geological Survey carried out continuous observations reported by Hamilton and Muffler (1972). In this test an array of eight seismographs was operated to examine the distribution of microearthquakes with respect to the location of the Geysers geothermal production. During the test period, 53 earthquake locations were determined within 10 km of The Geysers. Most epicenters lay in a zone about 4 km long and 1 km wide passing through the geothermal field along 4 km depth. Microearthquake magnitudes were not computed but were believed to be very small; the largest shock was estimated at a magnitude of 1 1/2 on the Richter scale.

An earlier 120-hour micro survey reported by Lange and Westphal (1969) reported 19 shocks, but the tripartite seismic array used did not permit accurate location of epicenters or focal depths.

## 5. Soils

There are eight major soil series in The Geysers KGRA. They are Butte, Henneke, Josephine, Konocti, Laughlin, Los Gatos, Maymen, and Yorkville. A detailed series description is included in Appendix G-1.

The Butte soils have medium acid, brownish-gray, loamy surfaces with strongly acid, white, clay loam subsurfaces over rhyolitic rock. They occur on moderately steep to steep upland slopes under conifer and oak vegetation.

The Henneke soils are weathered from serpentine-type rock. They are a brown to reddish-brown color and textured as loams to clay loams. Depths are shallow with bedrock occurring at less than 20 inches in depth. Soil fertility is low, usually needing chemical fertilizer applications to get responses from revegetation attempts.

The Josephine soils have medium acid, reddish-brown, loam surface layers and medium acid, light reddish-brown, clay loam subsurfaces. The fertility is moderately high and the subsoil permeability is moderate. They occur on steep uplands under a cover of conifers and hardwoods.

The Konocti soils have slightly acid, light reddish-brown, gravelly loam surface layers and slightly acid, light reddish-brown, gravelly loam subsurfaces over weathered basic volcanic materials. These soils are shallow to moderately deep ranging from 10 to 30 inches. They occur on steep to very steep slopes under cover of chaparral.

The Laughlin soils have medium acid, brown loam surface layers and medium acid, dark yellowish-brown, loamy subsoils. The fertility is moderate. They occur on moderately steep uplands under the woodland-grass vegetative type.

The Los Gatos soils have slightly acid, brown, loam surface and a medium acid, yellowish-red, clay loam subsurface. Depth to sandstone ranges from 20 to 40 inches. The shallower soils are ordinarily brushcovered and are found on south-facing slopes. The deeper soils are found on northern exposures with a cover of small trees and shrubs.

The Maymen soils consist of shallow soils 10-20 inches deep. They consist of medium to strongly acid, brown loam over yellowish-brown, medium acid, loam subsurface over fractured sandstone. These soils have numerous rock outcrops. Vegetation is predominantly chaparral.

The Yorkville soils have slightly acid, grayish-brown clay loam surface layers and mildly alkaline, mottled, dark grayish-brown clay subsoils. Depth to a dark gray or black substratum of metamorphosed basic and glaucophane shists varies from 30 to 60 inches. These soils are unstable and subject to slippage when subsoils are water-logged. These soils are typical of the north slope of Big Sulphur Creek. The majority of the national resource lands are made up of Los Gatos and Maymen with minor amounts of Henneke and Konocti soils.

## 6. Vegetation

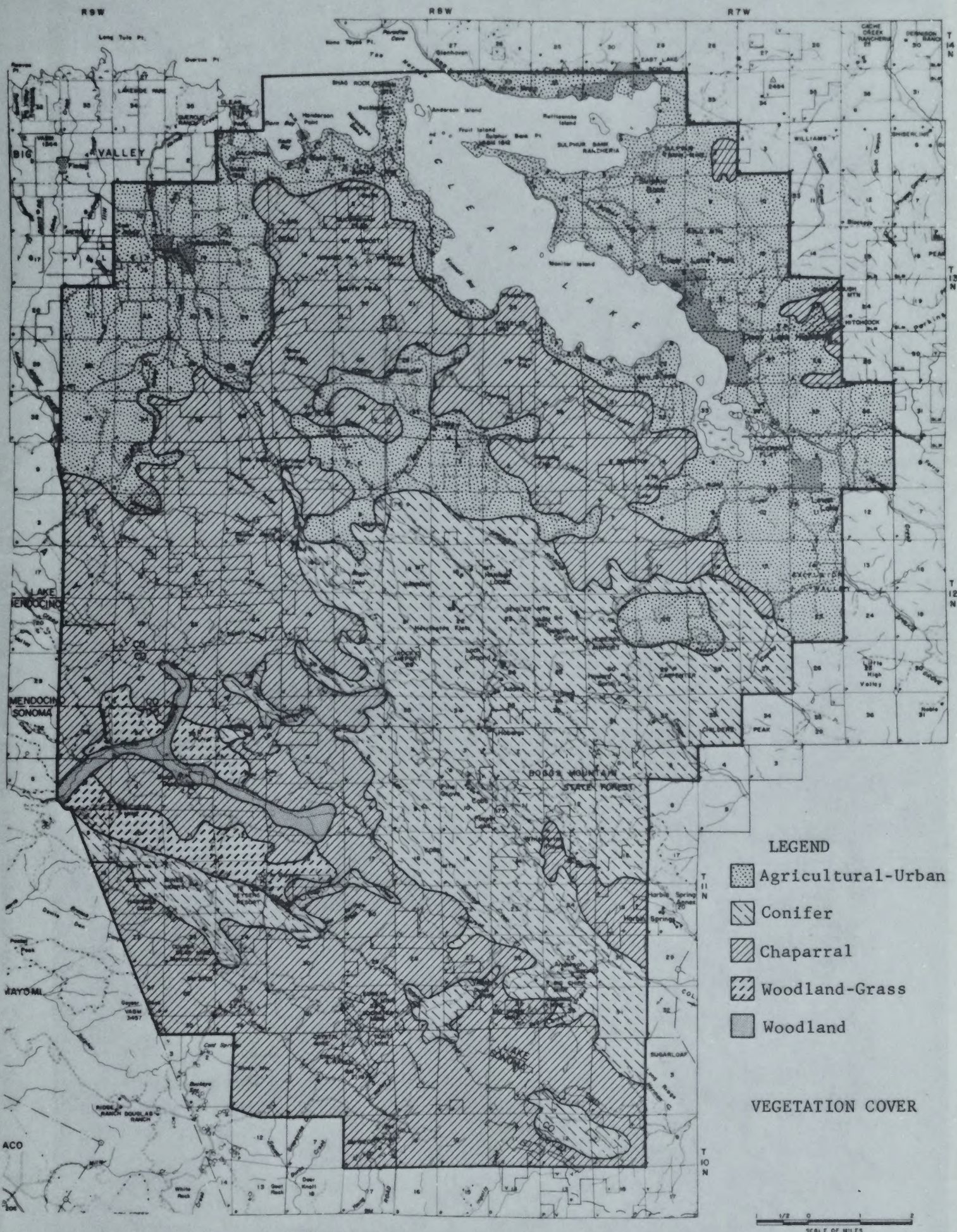
The Geysers KGRA lies on the northwestern edge of the Broad Sclerophyll (Oak-Chaparral) biome. The boundaries and the general characteristics are described in the general statement on the proposed Geothermal Leasing Program (page II-42 and page II-75). This biome is more generally referred to as the Woodland-Brushland Biome. The area is not entirely composed of woodland brushland, but has islands of vegetation that would normally be found in the northwest coastal coniferous forest, Montane coniferous forest, and the California prairie grasslands.

There are five major vegetative covers within The Geysers K.G.R.A. They are (1) cultivated and urban, (2) chaparral, (3) woodland-grass, (4) conifers, and (5) woodland (see Map G-2).

The major cultivated and urban areas are in the vicinity of Clear Lake. Orchards of pears, walnuts, and grapes are scattered throughout a five mile strip around the southern edge of Clear Lake (Photo G-3). A few orchards can even be seen on the steep sides of Mount Konocti, an extinct volcano on the shores of Clear Lake. Chaparral is the predominant vegetative cover in the unit. Chaparral consists of woody species that range in height from three to twelve feet, generally with rigid and thorny branches. The dense stands of shrubby plants are dominated by species that sprout vigorously after removal of the above-ground parts. The chaparral formation can be grouped into two broad subtypes: mixed-chaparral and chamise chaparral. The major species in the mixed-chaparral include California scrub oak (*Quercus dumosa*), manzanita (*Arctostaphylos* spp.), western mountain mahogany (*Cercocarpus betuloides*), and chamise (*Adenostoma fasciculatum*) with minor amounts of toyon (*Photinia arbutifolia*), poison oak (*Rhus diversiloba*) and California laurel (*Umbellularia California*).

The chamise-chaparral stands are dominated by chamise with minor amounts of associated species, such as manzanita and scrub oak (Photo G-4). The woodland-grass consists of open stands of broadleaved trees and digger pine (*Pinus sabiniana*) with grass and other low herbaceous vegetation forming an understory (Photo G-5). Some of the broad-leaved trees are Interior live oak (*Quercus wislizenii*), black-oak (*Q. kelloggii*), and California buckeye (*Aesculus California*). The understory species include oat grass (*Avena California*), foxtail fescue (*Festuca megalura*), red brome (*Bromus rubens*), lupines (*Lupinus* spp.), broadleaf filaree (*Erodium botrys*), thistle (*Centaurea* spp.), and turkey mullein (*Eremocarpus setigerus*).

The conifer cover, which predominates in the central to southeastern portion of the area, consists of Douglas-fir (*Pseudotsuga menziesii*), and yellow pine (*Pinus ponderosa*) with an understory of mixed-chaparral. Scattered stands of knobcone pine (*Pinus attenuata*) are located throughout the area. They often form thick dog hair density stands. Small patches of Douglas-fir occur throughout the area along canyon bottoms and north facing slopes (Photo G-6). These isolated patches are usually mixed with California live oak, madrone, scrub oak, California laurel and other minor species.



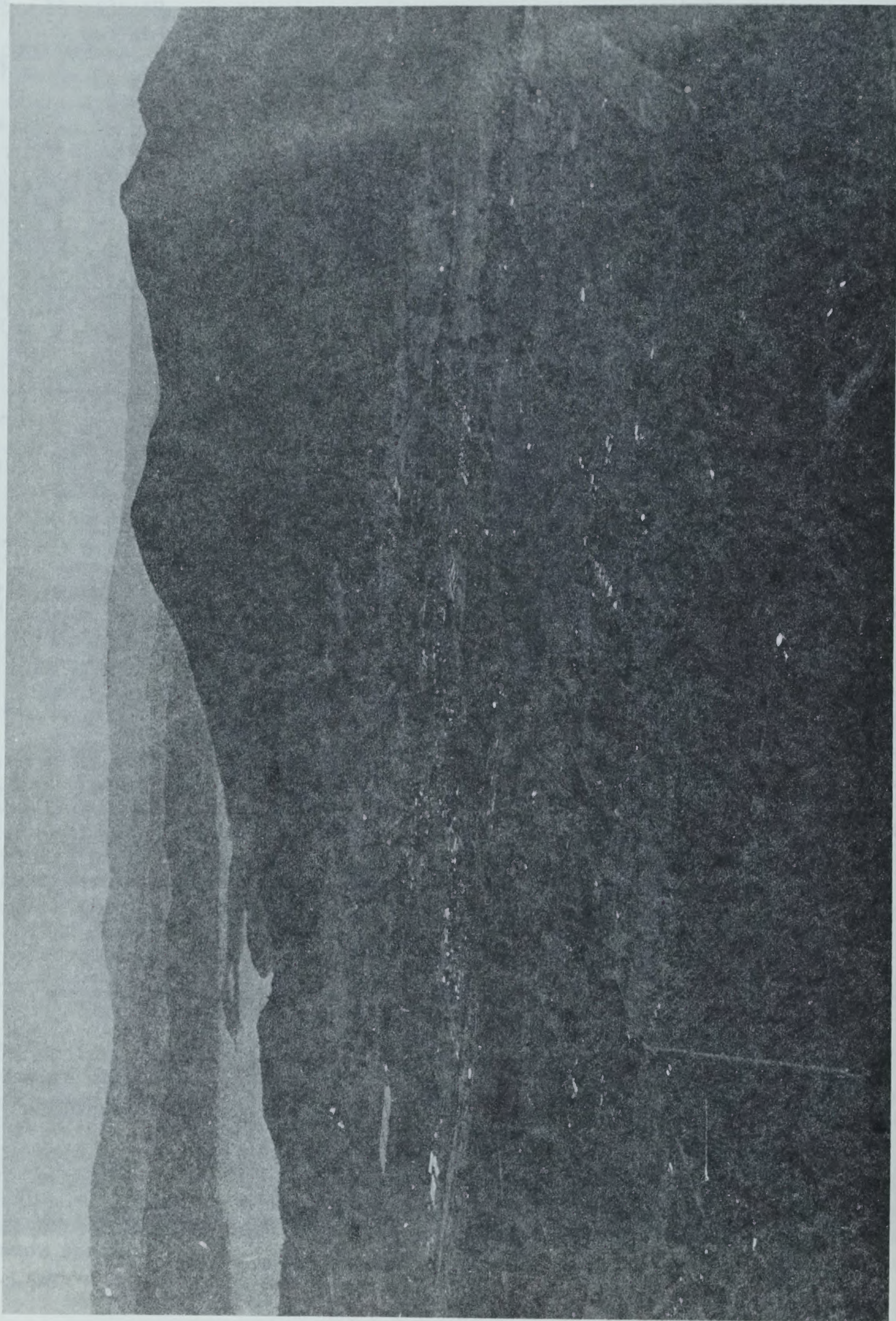


Photo G-3 - Cultivated and urban areas south of Clear Lake



Photo G-4 - Chamise Chaparral

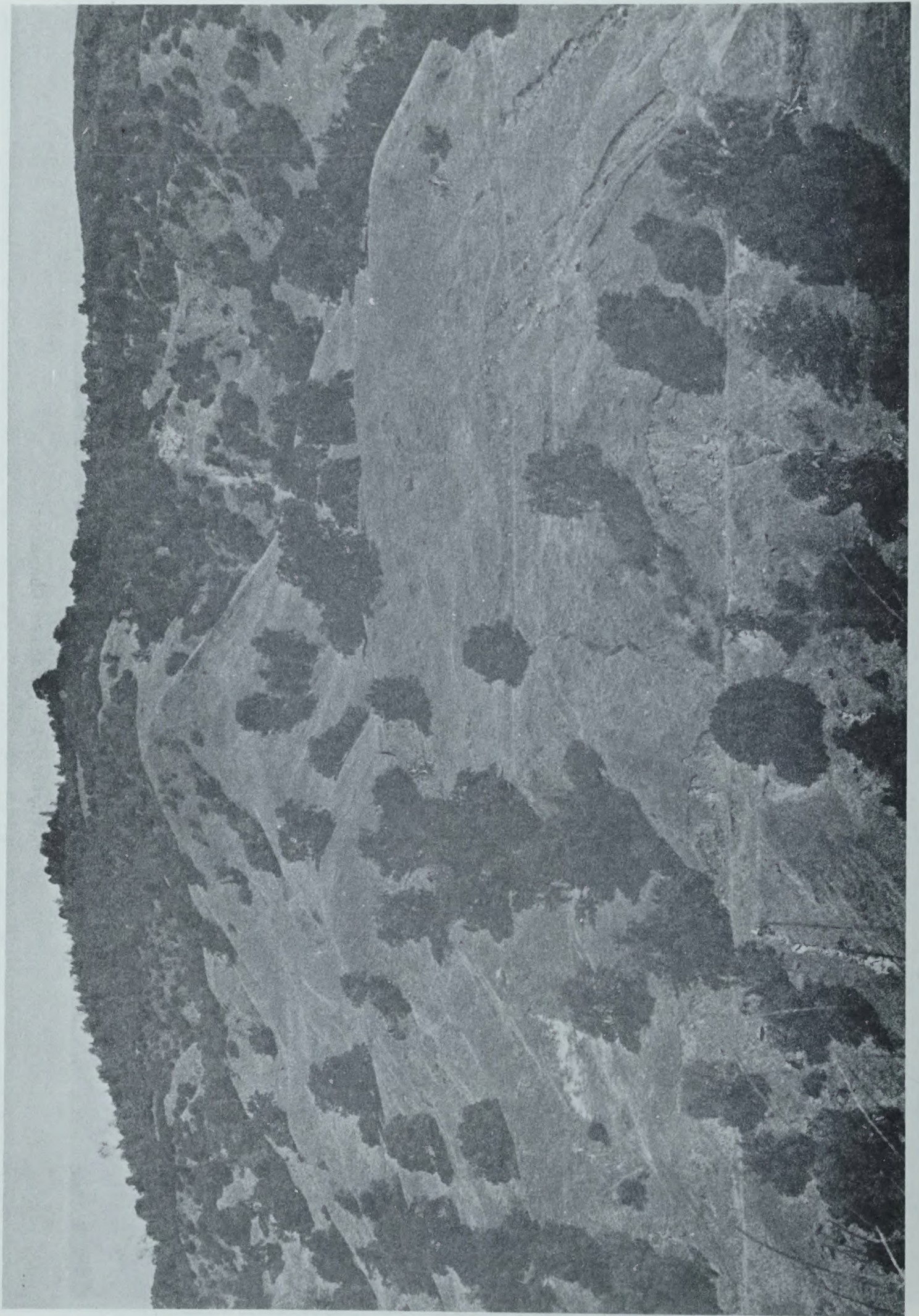


Photo G-5 - Woodland-grass vegetative type, mixed-chaparral on top of the ridge



Photo G-6 - Isolated stands of Douglas-fir interspersed with Chamise Chaparral and mixed Chaparral

There are scattered stands of Sargent cypress (*Cupressus sargentii*) on the ridges bordering the northern portion of Kelsey Creek. This particular cypress is usually associated with the Henneke soil series. The vegetation consists of cypress, leather oak (*Quercus durata*), and manzanita. Very few forbs or grasses are found in a dense stand of cypress; however, in a thin stand, perennial grasses provide ground cover and forage. The following browse plants are found in this vegetation type: leather oak, wedgeleaf ceanothus (*Ceanothus cuneatus*), toyon, manzanita, and deerbrush (*Ceanothus intergerrimus*), as well as several species of perennial grasses.

## 7. Land Use

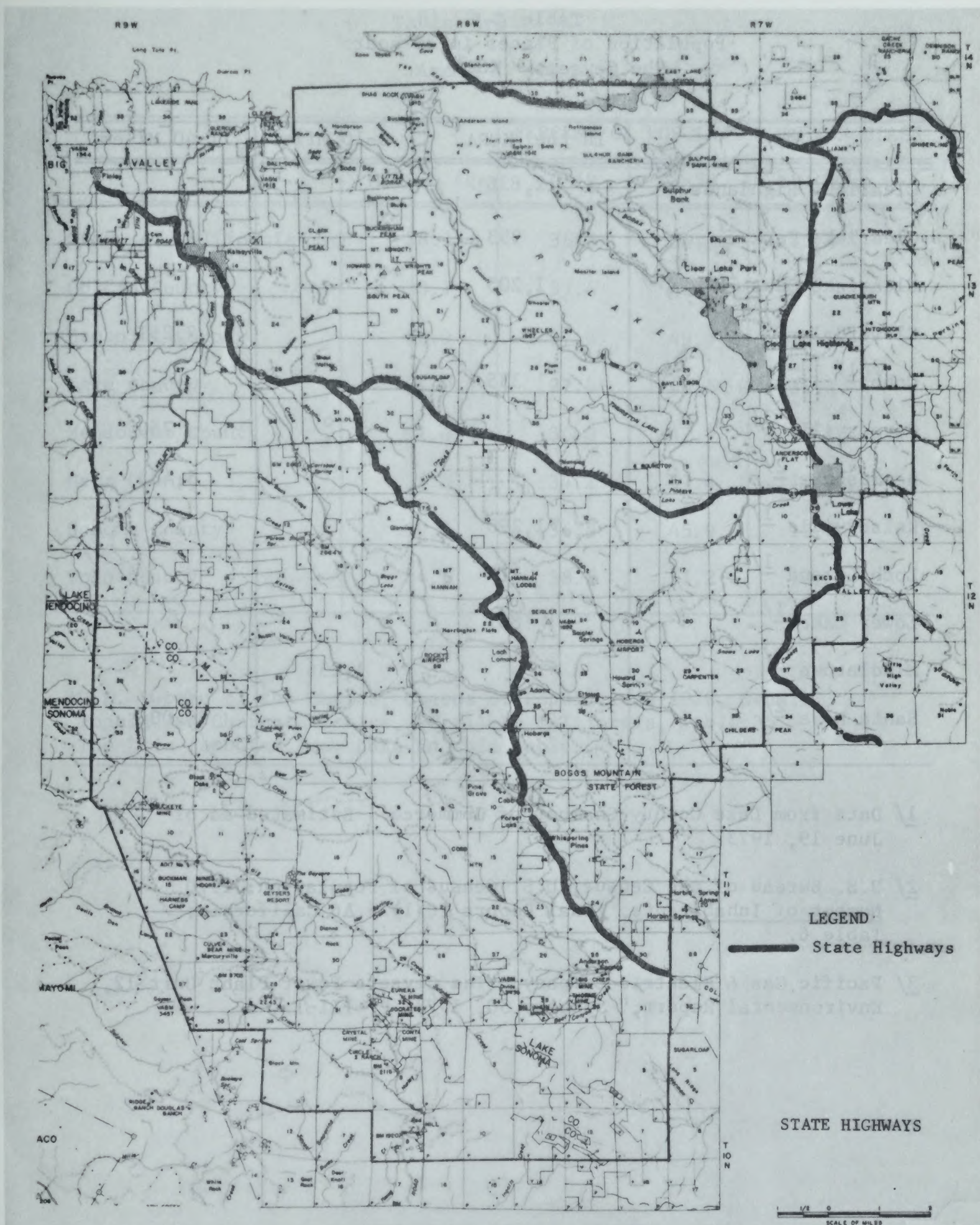
### a. Population Characteristics

The use of land is affected by the size of the human population and its distribution. The permanent population living within The Geysers K.G.R.A. is about 10,000 people. Most of these people live in a strip around Clear Lake and in the adjacent valleys where fruit and nut production occurs. A much lesser concentration of people occurs along Route 175 near the center of the KGRA in the Cobb Mountain area (see Map G-3 and Table G-5). The rest of the KGRA is very sparsely populated.

Overall population density for The Geysers KGRA is best represented by the Lake County population density of 15.5 persons per square mile (U.S. Census, 1970). This contrasts with the California average of 127.6 persons per square mile. Again using Lake County statistics as representative of the entire KGRA, the population increase is not explained by per capita income, \$2,772 in Lake County versus a California overall per capita income of \$3,632 (U.S. Census, 1970). These statistics relate only to those people who reside in the area on a permanent basis. The actual number of people in the area fluctuates widely with tourism. The same areas in which the permanent population is concentrated are also the areas which attract tourists. Therefore, the number of people varies from winter to summer, with summer being the season of greatest concentration.

The people living in the KGRA tend to be older than those living elsewhere in California (see Table G-6). The median age of persons in Lake County is greater than any other county in California. Since there is relatively little opportunity for employment, much of the influx is retired people.

It is important to note the location of the population relative to the location of the areas where the government owns mineral rights or fee title. The lands in government ownership are some distance from the population concentrations.



V-33

KNOWN GEOTHERMAL RESOURCE AREA

CLEAR LAKE-GEYSERS AREA

Map G-3

Table G-5  
Population of Places in or near  
The Geysers KGRA

	In the KGRA	0-10 Miles	11-40 Miles
Clearlake Highlands <sup>2/</sup>	2,836		
Clearlake Park <sup>1/</sup>	993		
Clearlake Oaks <sup>1/</sup>	1,205		
Cloverdale <sup>2/</sup>			3,251
Cobb <sup>1/</sup>	335		
Geyserville <sup>3/</sup>			750
Healdsburg <sup>2/</sup>			5,438
Kelseyville <sup>1/</sup>	1,290		
Loch Lomond <sup>1/</sup>	115		
Lower Lake <sup>1/</sup>	887		
Middletown <sup>1/</sup>		1,236	
Santa Rosa <sup>2/</sup>			50,006

<sup>1/</sup> Data from Lake County Chamber of Commerce. Estimated as of June 19, 1973.

<sup>2/</sup> U.S. Bureau of the Census, U.S. Census of Population: 1970, Number of Inhabitants, Final Report PC(1) - A6 California; Table 6.

<sup>3/</sup> Pacific Gas & Electric Company, "The Geysers Power Plant Unit 12, Environmental Report," January 30, 1973; P. III-1.

Table G-6

Age\*

	Median Age	PERCENT OF POPULATION IN AGE CLASS		
		Age Class		
		0-19	20-59	60/Over
State of California	28.1	36.8	50.3	12.9
Colusa County	30.7	37.4	46.2	16.3
Humboldt County	26.9	37.9	49.3	12.8
Lake County	47.0	27.4	40.5	32.1
Mendocino County	31.4	36.0	47.9	16.1
Napa County	32.3	34.2	47.4	18.3
Sonoma County	29.8	36.5	45.9	17.6
Yolo County	24.5	38.5	51.2	10.2

\*U.S. Bureau of the Census, Census of Population: 1970, General Population Characteristics, PC (1)-B6 California, Table 35.  
The % is computed from data in this table.

## b. Federal Land Ownership

The Federal Government has land in two types of ownership in The Geysers KGRA. Part of the area is national resource land (full fee ownership to the Government). This means ownership of both surface and subsurface rights. The other type of ownership is mineral rights only. On these lands, the Government does not own the surface rights. Its ownership of mineral rights is the result of their retention at the time the surface was transferred from Federal ownership. The land area with Federal mineral rights only is greater than that in full fee title to the Government (see Table G-7).

Table G-7  
Land Ownership in  
The Geysers KGRA

	<u>Acres</u>	<u>Percent</u>
National resource land	11,150 acres	7
Private land-Government mineral rights only	14,000 acres	8
Other lands - state and private	<u>138,278 acres</u>	<u>85</u>
TOTAL AREA	163,428 acres	100

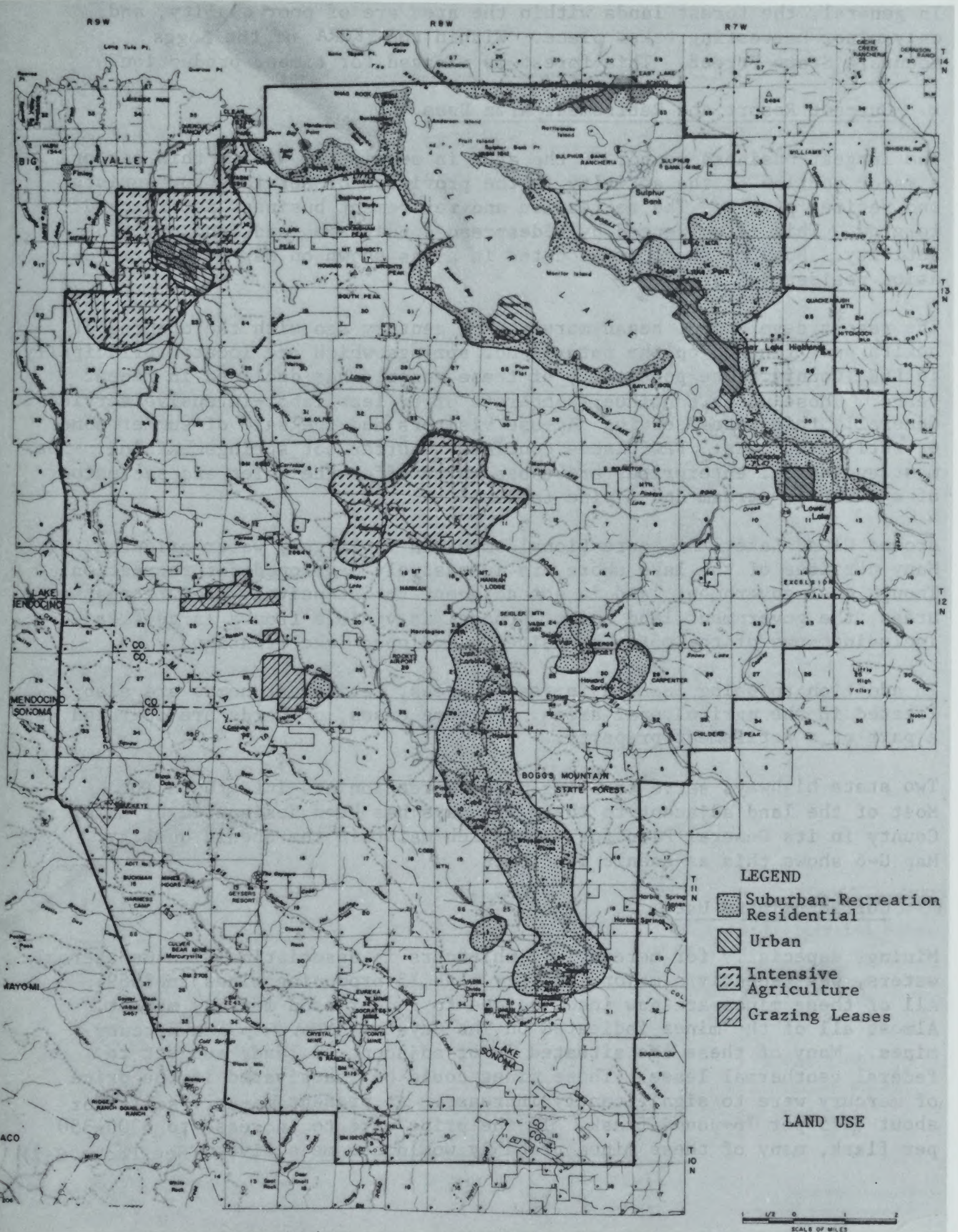
Major Federal ownerships are in the western and southern portions of the KGRA. The ownership pattern is indicated on the various maps included in this section and on the larger scale map in the pocket at the end of this volume. Large blocks of Federal ownership (national forest and/or national resource lands) occur north and east of the Geysers KGRA.

## c. Private Lands

Private lands comprise about 85% of the total lands in The Geysers KGRA. The principal economic enterprises in The Geysers KGRA are agriculture, resorts, recreation services, land subdivision, and geothermal power. Each of these enterprises is discussed in a current land use context in the following sections. Most of the land area and economic activity in the KGRA is in Lake County, but to date most of the geothermal activity has been in Sonoma County.

## d. Current Agricultural Use

Production of agricultural crops is the second largest business sector in the area. Agricultural crops are grown mainly on the level valley lands along the principal streams and on level land surrounding Clear Lake. Agriculture in the rest of the area is limited to dry pasture and orchards with only minor amounts of irrigated cropland (refer to Maps G-4 and G-2.) The mountain land, owing to steep slopes and long dry periods, is suitable mainly for rangeland and as wildlife habitat.



In general, the forest lands within the area are of poor quality, and only minor harvesting takes place. Within the KGRA of the Boggs Mountain State Forest. This forest is managed for timber production.

e. Current Resort and Retirement Area Uses

The largest business sector in the area is services. Within this sector, a major portion of the activity is the provision of services to tourists and retired people. The recreation and retirement business is expected to grow. This is evidenced by widespread subdivision and land division activity. Some of these are located in areas shown on Map G-5 as recreation residential areas.

The resort development began more than a century ago with the opening of health spas founded on the natural hot springs which are located principally in Lake County. The popularity of these resorts has declined in recent years. Those which continue to operate offer less labor-intensive services. Generally this means serving day-use visitors and the sale of summer home or retirement lots. Few places continue to offer hot springs bathing. The most successful enterprises are those which offer the quiet and seclusion of a mountain stream and a pine forest.

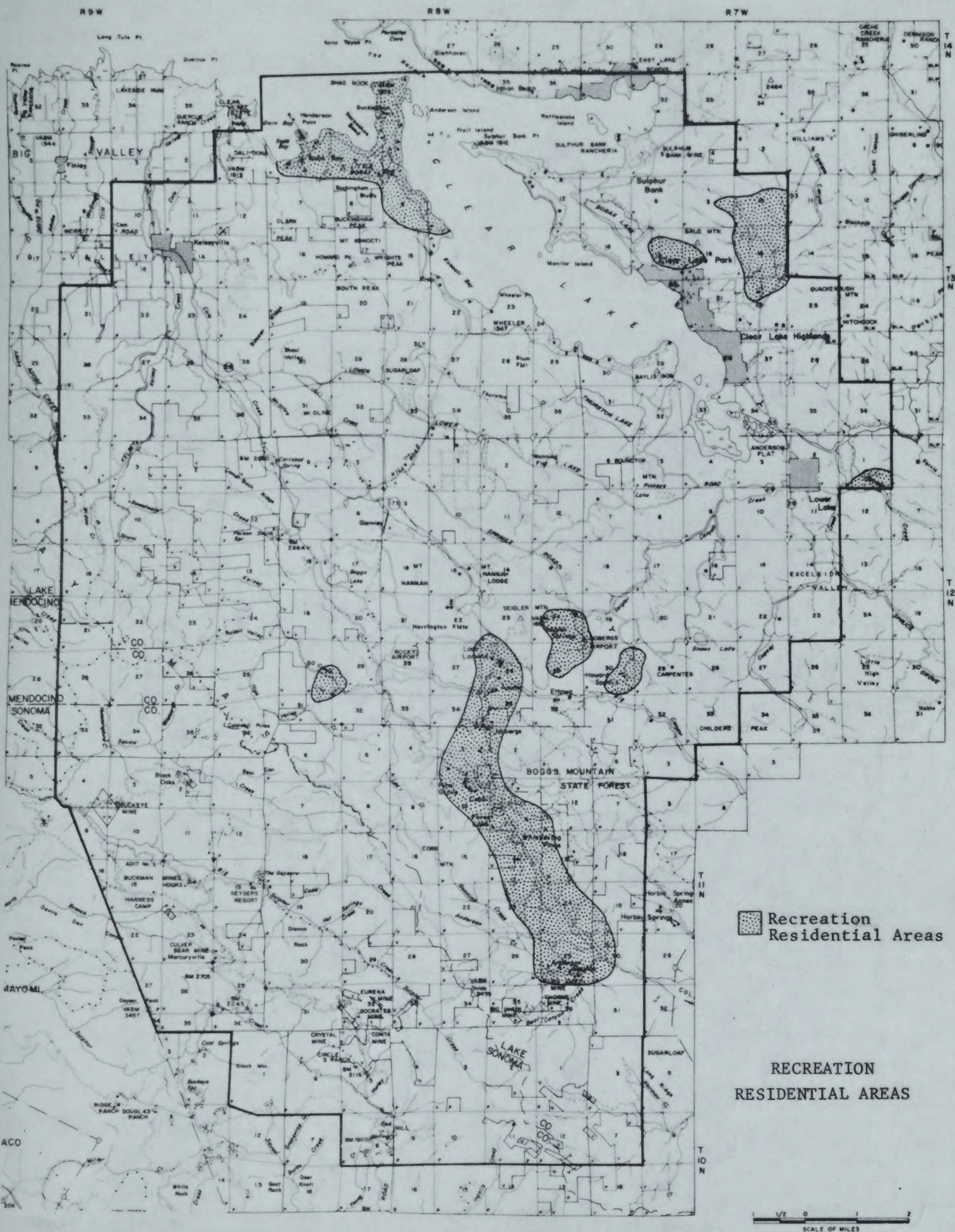
Around Clear Lake, the recreational emphasis is largely water oriented. Many portions of the lake shore are intensively developed for recreation. Though most government land is not adjacent to intensively used recreation areas, the government land on Mt. Konocti is visible from a large area including some of the most intensively developed lake frontage.

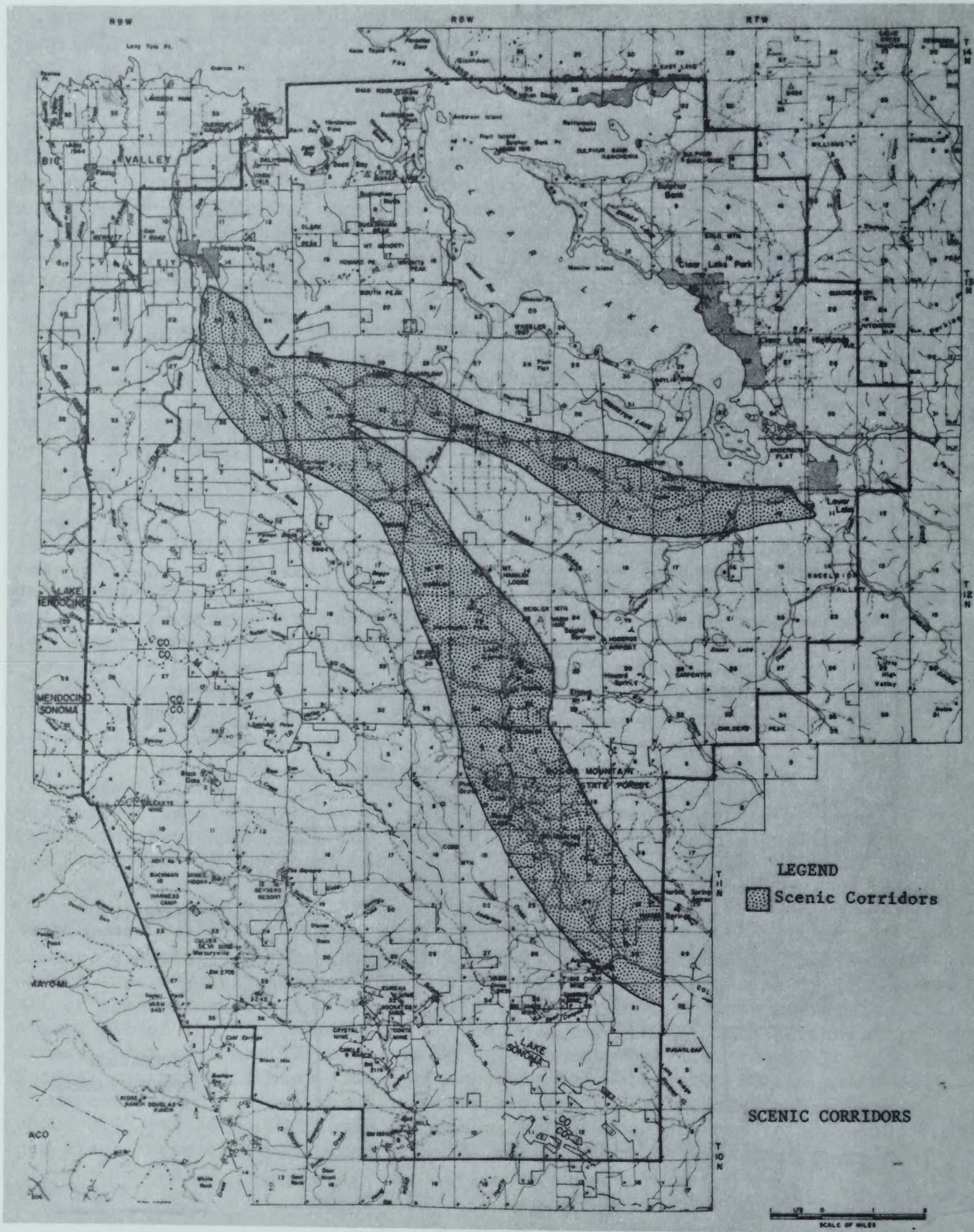
In addition to being located in resort areas, retirement homes are also located in the agricultural areas. In some cases, orchards are operated as a part of a retirement property.

Two state highways serve to bring most recreationists into the KGRA. Most of the land adjacent to these highways has been designated by Lake County in its General Plan for uses which maintain the scenic quality. Map G-6 shows this as scenic corridors.

f. Current Mining Use

Mining, especially for mercury, which occurs in association with Geothermal waters, was recently a major industry with 15 producing mines in 1969. All of these mines are now inactive due to a depressed mercury market. Almost all of the mines indicated on The Geysers KGRA map are mercury mines. Many of these are situated in or adjacent to lands subject to federal geothermal lease. These mines could be reactivated if the price of mercury were to significantly increase. At present mercury sells for about \$275 per 76-pound flask. If the price were to increase to \$300-350 per flask, many of these mines probably would become active. (See Photo G-7)





V-40

KNOWN GEOTHERMAL RESOURCE AREA  
CLEAR LAKE-GEYSERS AREA

Map G-6

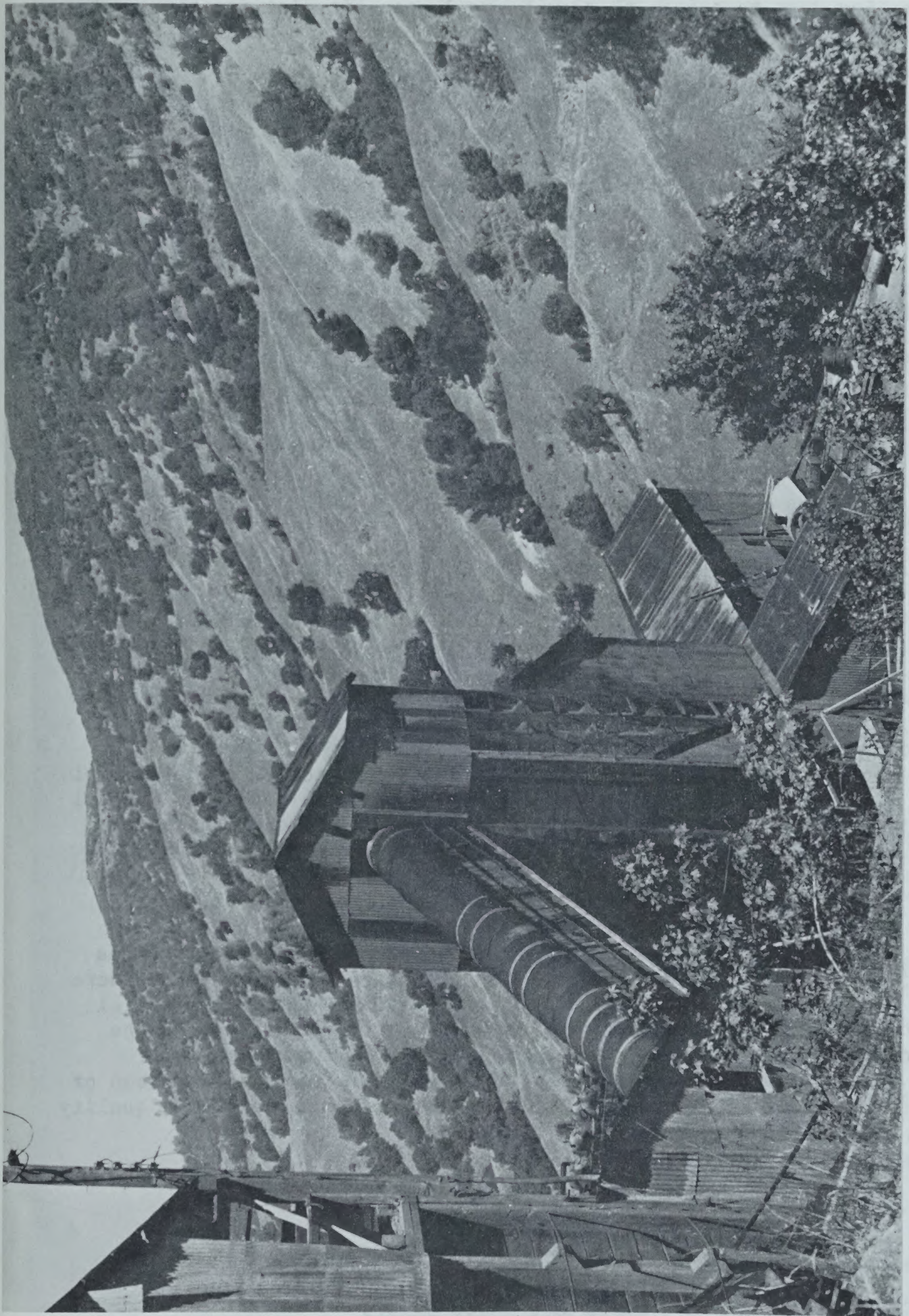


Photo G-7 - Buildings at an inactive mine on the road to the Geysers Resort. Prime virgin mercury was produced here from cinnabar

In the Mt. Konocti area there is also a small open pit mine for the production of building stone. This stone is very popular in the area for use in landscaping.

g. Current Geothermal Land Use

The only developed power producing geothermal field in the United States is at The Geysers in the southwestern part of the KGRA. This field is one of only four known dry steam producing areas in the world. (Photo G-8)

All of the existing natural steam powered generating facilities at The Geysers are on private land in Sonoma County. Drilling is currently taking place in both Sonoma and Lake Counties. Most of this development is in the Sulphur Creek drainage in the southern part of the KGRA.

Considerable interest is expected for the leasing of the federally owned potential geothermal resources within or adjacent to the Sulphur Creek area. Additional information on land use for geothermal power is presented elsewhere in this report.

h. Current Use of Federally Leasible Lands

Approximately 14,000 acres within the KGRA is in private ownership with minerals reserved to the government. Almost all of this land is mountainous and is covered with chapparral brush (see Map G-1 and Map G-2). Where used for agriculture, the land is grazed to a low intensity by range livestock. There are a few places in the northern part of the KGRA where there appear to be orchards on these mineral reserved lands. Though these lands are in low population density areas, there are a few homes or cabins located on them. In the southern part of the KGRA there are many cinnabar mines. Frequently these occur on or adjacent to the mineral reserved land. Also, a part of the building stone mine in the Mt. Konocti area is on land where the mineral rights are reserved to the government, and part is on national resource land.

Most of the 11,150 acres of national resource land are in isolated mountainous, brush-covered parcels less than one section in size. There are two small grazing leases on approximately 900 acres. One authorizes 92 AUM's (animal unit months) and the other 36 AUM's (see Map G-4). There are mining claims on some of the lands. None of these is in commercial production. Hunting use of this land is generally light because of the absence of public road access. Other types of recreational use are similarly restricted. Management of these lands has, in the past, been of a protective nature. The emphasis has been upon maintenance of the quality of the watershed.

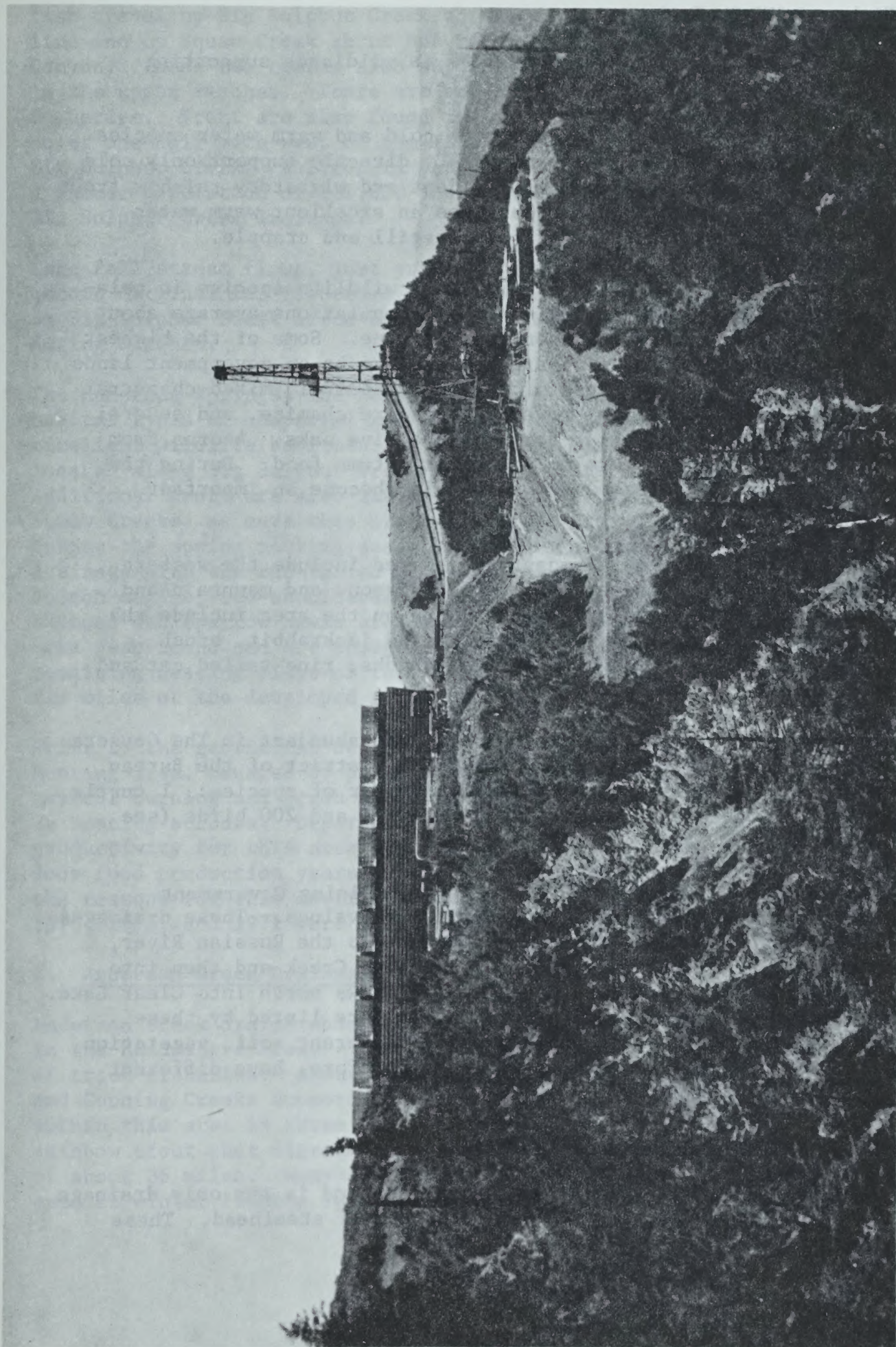


Photo G-8 - Geothermal development: a power generating plant and a steam well drilling rig on private land at The Geysers

## 8. Fish and Wildlife

Most of the area within The Geysers KGRA is wildlands supporting abundant populations of fish and wildlife.

The fisheries for this area include both cold and warm water species. However, the grandfather clause and N.R.L. directly support only cold water game species, which includes resident and migratory rainbow trout and resident brown trout. Clear Lake has an excellent warm water fishery of large-mouth bass, catfish, bluegill and crappie.

The black-tailed deer is the most important wildlife species in relation to hunting and observational values. Populations average about 30 per square mile, depending upon habitat type. Some of the highest deer densities (80-100/sq. mi.) are believed to be on government lands which support mixed cover types of chamise chaparral, mixed-chaparral and some conifer. The major browse species are chamise, and several species of ceanothus and shrub forms of the live oaks. Acorns from black, blue and live oaks are an important autumn food. During the winter months, annual grasses and forbs also become an important part of the diet.

Other game animals locally abundant and hunted include the western gray squirrel, mourning dove, band-tailed pigeon, and mountain and valley quail. Other mammals that are found on the area include the mountain lion, bobcat, gray fox, black-tailed jackrabbit, brush rabbit (cottontail), striped and spotted skunks, ring-tailed cat and the raccoon.

Non-game wildlife species are also diverse and abundant in The Geysers KGRA. A check list compiled by the Ukiah District of the Bureau of Land Management includes the following number of species: 1 turtle, 13 snakes, 17 amphibians, 6 lizards, 54 mammals and 200 birds (see Appendix G-3).

The Geysers KGRA includes three drainages containing Government lands which have significant fish and wildlife values. These drainages are (1) Big Sulphur Creek, which flows west into the Russian River, (2) Anderson Creek, which flows east into Putah Creek and then into Lake Berryessa, and (3) Kelsey Creek, which flows north into Clear Lake. The continuing fish and wildlife descriptions are listed by these individual drainages, as each has somewhat different soil, vegetation, water and topographic characteristics and therefore, have different fish and wildlife values.

### a. Big Sulphur Creek Drainage

Big Sulphur Creek drains about 53 square miles and is the only drainage in this KGRA supporting an anadromous fishery of steelhead. These

fish travel up Big Sulphur Creek to the vicinity of the Lake-Sonoma County line and up Squaw Creek about one mile upstream from the mouth of Bear Canyon. These two creeks also support resident rainbow trout, but mainly in the upper reaches. There are about 18 miles of stream supporting these fisheries. Trout are also found in Little Sulphur Creek but only from a point one-half mile west of the KGRA boundary to its confluence with Big Sulphur Creek. California Department of Fish & Game surveys indicate a summer population of 131,000 young steelhead and resident trout in the Big Sulphur Creek drainage.

Late fall stream flows, just prior to the first winter rains, often become marginal for fisheries purposes. Flows at The Geysers Resort area on Big Sulphur Creek often drop to less than 0.5 cubic feet per second during October.

The numerous springs, the several streams and tributaries, and the mixed habitat types of chaparral and conifers combine to provide good to excellent wildlife habitats. A great blue heron rookery of six nests is located along Big Sulphur Creek near the western boundary of the KGRA. Additional nests are also likely along other portions of Big Sulphur and Squaw Creeks, as more than 12 adult herons are known to use this area during the spring nesting season. Raptors are also commonly seen in the drainage with the red-tailed hawk and turkey vulture the most abundant. Golden eagles, red-shouldered, rough-legged, goshawk, cooper's, sharp-skinned and sparrow hawks are also commonly seen. Golden eagles use the area year-round and are thought to nest in the area. One of the few remaining nesting sites of the endangered peregrine falcon is within 20 air miles of the developed geothermal area.

Prior to the geothermal development, this drainage was a favorite deer hunting area, managed by private deer hunting clubs. Management included control burning and brush crushing which improved deer habitat, as well as hunting success. Department of Fish & Game biologists report that productivity for this area has been declining over the last four years. Poor food production years and geothermal development are thought to be the reasons for this decline. Spring fawn counts (fawns/100 does) for 1973, 1972, and 1971 were 37, 41 and 47, respectively.

b. Anderson Creek Drainage

Anderson Creek drains about 10 square miles with most government lands in the headwaters area. This drainage supports three different types of trout fisheries. About seven miles of the upper reaches of Anderson and Gunning Creeks support a resident rainbow trout population. Included within this area is three and a half miles of stream used by spawning rainbow trout that migrate up Putah Creek from Lake Berryessa, a distance of about 36 miles. Many of the spawners weigh over two pounds, and a special winter fishing season from January 1 through February has been

established for the area between Highway 29 and Anderson Springs. The third trout fishery is from planted, catchable-sized fish. An average of 6,500 fish per year are planted in the Anderson Springs recreation area which is within the KGRA. This program supports 1,900 angler days per year.

Water flow measurements taken in 1970, near Anderson Springs showed that although flows remain sufficient in late summer to support trout, any water loss may be detrimental to fish life. Flows ranged from 7.7 c.f.s. in April to 1.5 c.f.s. in October.

Deer densities are probably a little higher than those in the Big Sulphur Creek drainage because of the better soils and overall better habitat conditions. The deer that occupy the higher areas during the summer migrate short distances (probably up to 4 or 5 miles) to lower elevations during the winter.

#### c. Kelsey Creek Drainage

Kelsey Creek drains about 45 square miles and is somewhat unique for this part of the state as it supports a self-sustained brown trout population as well as rainbow trout. Approximately 24 miles of stream support trout. Fish occur up Kelsey Creek as far as the Forest Lake area. The lower reaches of Widow, Sweetwater, High Valley and Alder Creeks also support trout. In addition to the native fisheries, from 1,000 to 6,000 catchable trout have been planted annually in upper Kelsey Creek. A total of 8,000 angler use days per year has been estimated for this drainage.

Some migrational movements of deer probably occur in the upper reaches of Kelsey and High Valley Creeks. Deer in most other areas are resident. Other wildlife use is similar to the other two drainage areas.

### 9. Recreation

Lake County is the principal county within the KGRA. Because of the county's natural lakes and scenic mountains and its proximity to the San Francisco and Sacramento metropolitan areas, tourism has become one of the major economic uses. Intensive recreation development has occurred mainly in two areas, Clear Lake and Cobb Mountain.

Clear Lake is the largest natural lake totally within California. Commercial development and the utilization of the lake's recreation resources commenced over 100 years ago.

The southern part of the lake is within the KGRA and the surrounding land mostly is in private ownership. Federal ownership within 4 to 5 miles of this portion of the lake is nominal and in scattered tracts. Potential geothermal leasing for such lands would, in most instances, probably have to be accomplished in conjunction with adjacent private lands. Although only 20 percent of the lake is in the KGRA, it has about two-thirds of the lake's resorts, trailer parks and related commercial facilities.

Clear Lake State Park is located partially within The Geysers KGRA on the west side of the lake. In 1972, nearly 84,000 people used this area for camping, boating, swimming and other water-oriented recreation uses.

Most of the recreation use occurs in the summer. The primary recreation pursuits are boating, water skiing, fishing, and swimming.

The forested Cobb Mountain area, in the center of the KGRA flourished as a resort area from 1870 to 1930. Most of the resorts were established near mineral springs. These resorts were well known for their health cure activities. Several of the resorts could accommodate over 500 guests. After 1930, there was a gradual trend away from the resort type vacation. Today most of these old resorts are abandoned and have been replaced by motels, trailer parks, and numerous vacation homes. The cool and quiet forest atmosphere is the main attraction, although hiking, horseback riding, golf, and swimming are also popular.

Adjacent to Cobb Mountain is the 3,300 acre Boggs Mountain State Forest which received 1,870 recreation visitors in 1972. All of the State Forest and most of the adjacent Boggs Mountain area are within the KGRA.

The balance of the KGRA, including Sonoma and Mendocino County portions, has very limited recreation use. The chaparral-covered hills and woodland-grass-covered valleys are used for hunting. Most of the land is privately owned with restricted public access. The scattered national resource lands, for the most part, do not have public access.

Hunting clubs are common throughout the area, and for a fee the public may indulge in this sport. The Federally owned land within the KGRA does not have primitive area characteristics.

The California Public Outdoor Recreation Plan forecasts that in 1980, recreation use in Lake County will exceed five million activity days - 43 percent being devoted to fishing, 17 percent to boating, 12 percent to swimming, 9 percent each to picnicking and camping, 3 percent each to hunting and community activities, and 1 percent to riding and hiking.

## 10. Aesthetic Features

The aesthetic values for The Geysers KGRA can best be described by separating this area into the three geographical zones: Clear Lake, Cobb Mountain-Boggs Mountain, and Mayacmas Mountains.

### a. Clear Lake Zone

It is a pleasing sight to view Clear Lake from a distance to observe its bluish-green waters and the brown and green-colored vegetation of the surrounding hills and mountains. Some of this pleasantness is lost when the lake is viewed from its shoreline. Piecemeal construction of low cost residences, motels, resorts, and trailer parks greatly detract from the natural setting of the lake and adjoining country-side. The use of septic tanks adjacent to Clear Lake has led to a sewage problem which has caused eutrophication of the lake waters. Normally by July this high nutrient content results in a large green algae bloom that persists for the rest of the summer and detracts from water contact sports.

The aesthetic values of Clear Lake are enhanced by the wildlife seen along its shores and on its waters. Wild, as well as domestic, ducks and geese are commonly seen, as well as gulls and grebes. Deer, valley quail, mourning doves, and song birds are seen along the shoreline and also in the adjacent land areas.

Almost as striking as the lake itself is Mount Konocti, an extinct volcano rising to almost 3,000 feet above the lake's surface. It is covered mainly by chamise and mixed-chaparral and is within the KGRA on the west side of the lake. The surrounding lands are relatively low in elevation, so this mountain can be seen from the entire lake area and from most of the adjacent areas ranging up to 20 miles distant. Besides the several orchards at the base of Mount Konocti, the only evidence of human activity is an unpatented mining claim at the 2,000 foot elevation level. This activity has exposed a whitish rock area that has high contrast to the chaparral-covered slopes. (Photo G-9)

Highway 29, which traverses the Clear Lake and Cobb Mountain-Boggs Mountain zones has been nominated for an official state scenic highway designation.

### b. Cobb Mountain-Boggs Mountain Zone

State Highway 175 generally follows Putah Creek from Middletown northwest to the creek's headwaters between Cobb and Bogg Mountains. Vegetative cover types change from the grain and orchard areas near Middletown to oak-woodland, chaparral, and pine-fir timber as elevation increases. In the higher conifer type a few small, isolated meadows



Photo G-9 - Looking north, Mount Konokti with Clear Lake in left background

can be seen from the road. In summer, this quiet and cool forest atmosphere is a welcome relief to travelers coming from the hotter, lower elevation areas.

c. Mayacmas Mountain Zone

This scenic zone is in the southwest portion of the KGRA. It includes land in Sonoma, Lake, and Mendocino Counties. The dominant colors are those associated with chaparral: dark greens and browns. Less dense vegetation on Henneke soils gives a reddish tint to the site. Stringers of pine are found in some stream drainages and on some north slopes. Because of very limited public access, only distant views are possible. In some areas surface mining has exposed the ground surface. Fire breaks and trails along the ridge are also highly visible. The contrast between the light-colored soils and the dark-colored chaparral detracts from the scenic quality.

## C. ENVIRONMENTAL IMPACT OF PROPOSED ACTION

A comprehensive discussion of potential environmental impacts associated with the development and use of geothermal resources is included in Volume I, Chapter III, Section B of this impact statement. This discussion will not be repeated here except to the extent it is needed as a background for evaluation of specific impacts for The Geysers KGRA.

Since the degree of potential environmental impacts of the proposed geothermal leases generally would be directly related to the proportion of Government to private land ownership, to the type of resource (hot water or dry steam), the status of private land resource development, and the probable sequence of geothermal operations, appropriate discussion of land status and the possible nature and sequence of geothermal operations is included here.

### 1. Resource Reconnaissance Stage

The reconnaissance stage of exploration in The Geysers KGRA has been largely completed. Shallow drilling was begun as early as 1921 and continued intermittently until major production was established on private land in the mid-1950's. Because of the great depth of the major producing zone and complex geology, the principal geophysical exploration has been gravity surveying. This involves occupation of a station with a portable gravimeter for a few minutes and has had no significant environmental impact.

It is expected that future exploratory work will concentrate on delineating the productive area by deep drilling. Geologic mapping, sampling of natural springs and wells, and additional geophysical work will continue until the field is well defined. These activities will, for the most part, use existing access routes.

### 2. Test Drilling and Production

This stage of development has been underway for many years on private land in The Geysers field and much experience is available on the environmental impact of drilling and testing, particularly in the vicinity of The Geysers Resort (Map G-1) in northeast Sonoma County.

#### a. Surface Effects

The major disturbance during the test drilling and production testing is road and well site construction (See volume I, Chapter III, Section B of the General Statement). This could be relatively severe because the steep mountainous terrain requires massive cut and fill work (Photo G-10). Level spots are almost nonexistent and generally about 1-3 acres of cut and fill is required to provide room for drilling operations (Photo G-11).

Road maintenance may be complicated in some areas by the unstable character of the Yorkville soils, noted for their susceptibility to massive landsliding. Maintenance on the more stable Los Gatos and Maymen soils is less demanding.

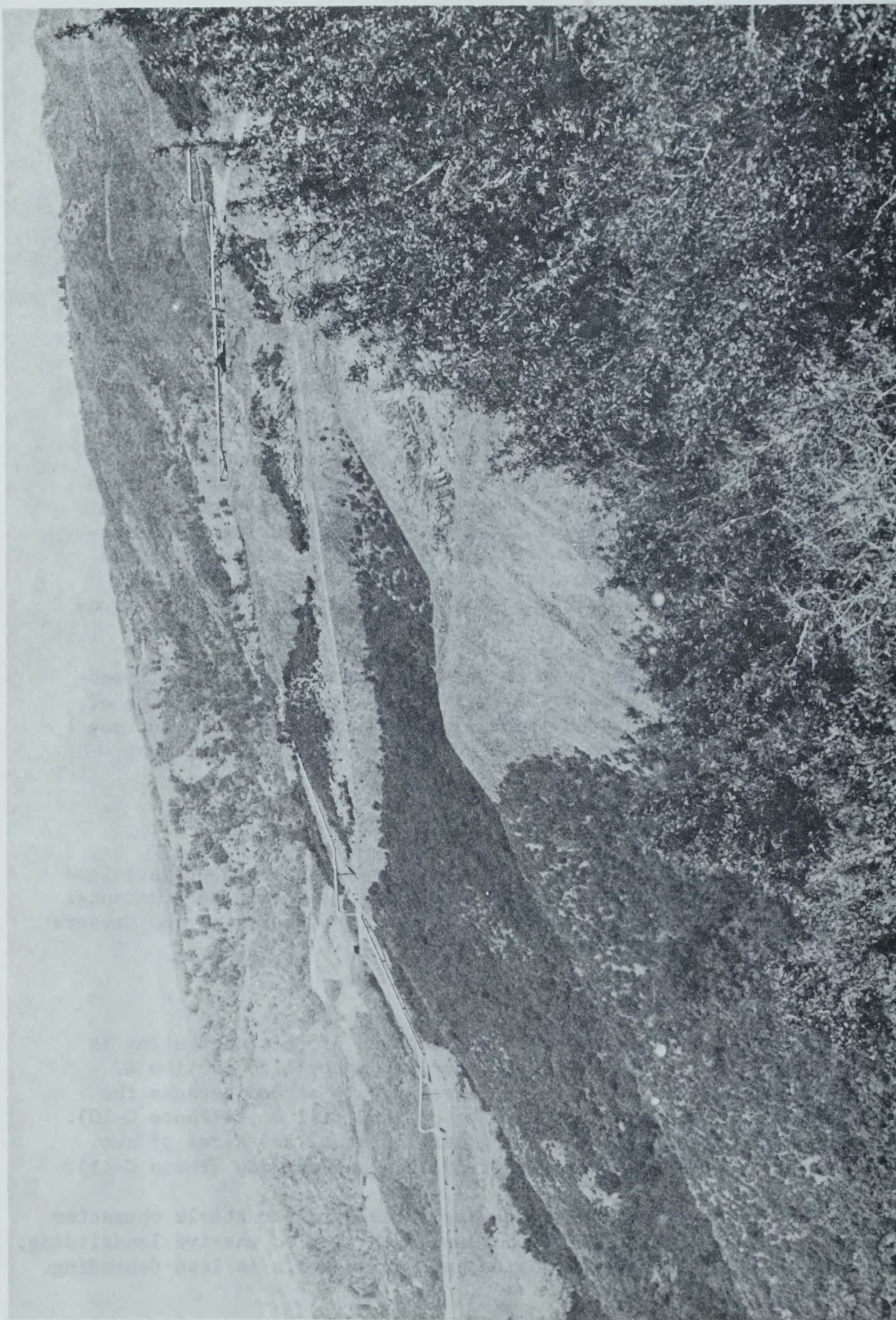


Photo G-10 - Extensive cuts and fills are necessary for road and well site development in this type of terrain

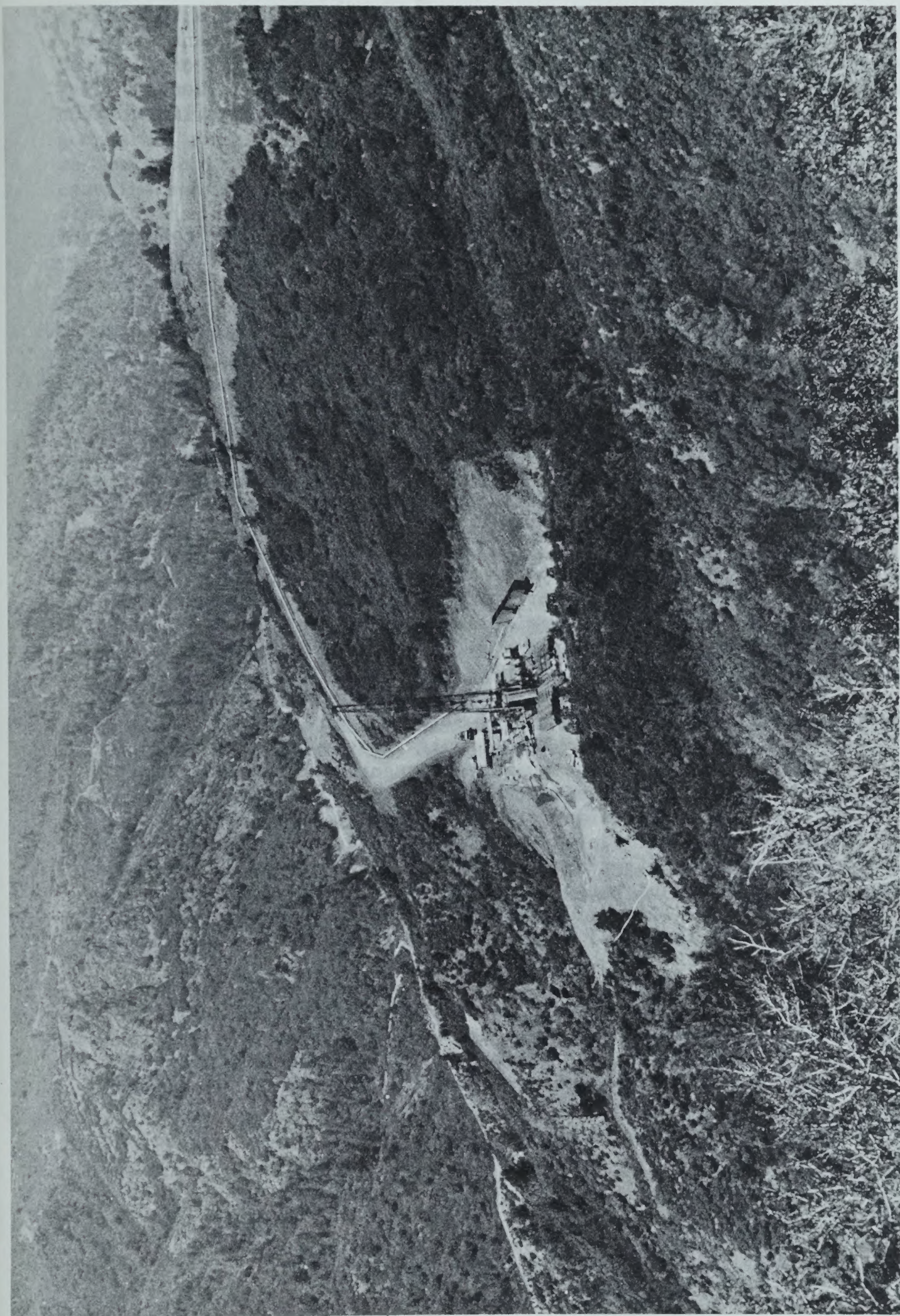


Photo G-11 - Well site pad

Increased temporary sediment production is highly probable as a result of such disturbance, especially on the Yorkville soils. The sediment problem can be ameliorated to a considerable degree when buffer strips of heavy brush are left between the area of disturbance and the stream bottom (Photo G-10). Other sediment control measures can be taken to limit soil movement (mats, water breaks, contour trenches, etc.).

#### b. Water Resources

The impact on water resources of geothermal test drilling and production testing to date has not been significant. Little water is used during drilling except for that required for drilling mud used in drilling the upper part of the well. However, any water diverted from the streams during late summer could have adverse effects on fish and other aquatic life as water flows are marginal from August through October.

After setting "surface casing" at about 2,000 feet, the holes commonly are completed by air drilling. The steam produced during drilling and testing discharges to the atmosphere; thus, there is no release of geothermal liquid to surface or ground waters. Where hot water has been encountered instead of steam, the wells have been shut in and not produced.

In the mountainous parts of The Geysers KGRA, superficial ground water from shallow wells is the supply for stock and domestic use. There is little hazard of adversely affecting this source by geothermal drilling and testing. A quite different ground water resource is the thermal springs of the area, which were the basis for the early health spa development in Lake County. Many, if not all, of these springs represent points of discharge of geothermal waters mixed to varying degree with superficial fresh ground waters. Thus, it is conceivable that geothermal drilling could affect the quality or quantity of discharge of such springs; however, no such effect has been reported to date. Even "The Geysers" springs in the midst of the geothermal field appear to be little affected by the nearby production from the deep geothermal reservoir, although discharge of steam from natural vents has been evidently reduced, as suggested by pictures predating the electric power development. The impact of drilling and production testing on streams would be mainly in the form of increased sediment load stemming from clearing and grading operations.

Additional test drilling and production testing contemplated in The Geysers KGRA is expected to have about the same impact as drilling to date. Impacts related to Federal lands probably will be less than will occur on private lands due to more restrictive environmental protection.

c. Air

During test drilling and production testing, air quality could be affected by an increase in the dust level generated by construction equipment and the movement of vehicles; by the release of gaseous vapors associated with geothermal steam; by pollutants from internal combustion engines and by an increase in the noise level. Chapter III of the General Statement contains ambient air tables showing quality standards for California and other States plus noise exposure levels which apply to geothermal activity pursuant to PL 91-596.

(1) Noise

The construction of drill pads and access roads and test drilling, combined with the transportation of men and materials to the well site, will create noise. Wells in The Geysers KGRA use either drilling mud or air as the circulating medium to remove rock cuttings. Mud is used in the upper part of the hole to the depth where the surface casing string is installed, generally at 2,000 feet. If the well is dry at this point, the operation is converted to air drilling. A moderate noise level is associated with mud drilling, but air drilling involves the higher noise level of the air compressors and the discharge noise of air and cuttings from the return-circulation line. The noise associated with the drilling of a particular well is of relatively short duration lasting 30 to 45 days. Upon completion of a producing well, it is tested to determine its productive capacity and to gain information on the reservoir characteristics. The testing period generally lasts a few weeks. Following the test the wells are generally bled continuously until they are connected to the generators. A time lag of several years generally occurs between the drilling of a test hole and the utilization of the steam at a generating facility.

A simple comparative analysis of noise levels at The Geysers and from other sources is presented in Table G-8. In summary, the operations producing the greatest amounts of noise are air drilling, well testing, and bleeding. The noise factor along with human activity has the greatest impact on the animal ecology. This is discussed in more detail in the Fish and Wildlife Section.

Table G-8

Comparison of Noise Levels Between  
The Geysers Area and Other Sources

<u>Geysers Area</u>	<u>Level</u>	<u>Distance</u>
<u>Source</u>		
Drilling Operation (air)	126 dB (A)	25 feet
Drilling Operation (air)	55 dB (A)	1,500 feet
Muffled testing well	100 dB (A)	25 feet
Muffled testing well	65 dB (A)	1,500 feet
Steam line vent	100 dB (A)	50 feet
Steam line vent	90 dB (A)	250 feet

Comparative Levels

Jet aircraft takeoff	125 dB (A)	200 feet
Threshold of pain	120 dB (A)	
Unmuffled diesel truck	100 dB (A)	50 feet
Street corner in a large city(Average)	75 dB (A)	
Residential area at night (Average)	40 dB (A)	

## (2) Gaseous Emissions

Noncondensable noxious gases, particularly hydrogen sulfide ( $\text{H}_2\text{S}$ ) emitted from the well during testing and bleeding pollutes the air. The gases associated with the geothermal steam produced at The Geysers in volume percent are as follows:

$\text{H}_2\text{O}$	$\text{CO}_2$	$\text{H}_2$	$\text{CH}_4$	$\text{N}_2$	$\text{H}_2\text{S}$	$\text{NH}_3$	$\text{P}_3\text{PO}_4$
98.045	1.242	0.287	0.299	0.069	0.033	0.025	0.0018

The  $\text{H}_2\text{S}$  is 16 times the human toxic level in the undiluted geothermal steam and ammonia ( $\text{NH}_3$ ) is five times the toxic level. A rotten egg's odor of  $\text{H}_2\text{S}$  is noticable in and around the developed area. The impact of these emissions is discussed in the various resource components that follow. Also, gaseous emissions from The Geysers are discussed in Volume I, Chapter III, Section B of the general section of the statement.

### d. Vegetation

The construction of access roads and well sites will result in both temporary and permanent destruction of the vegetation on those sites (Photo G-12). The access roads, use areas around the developed wells, and steep rocky cuts will usually remain devoid of vegetation. Fills and cuts that have a soil cover will slowly revegetate naturally or revegetation can be accelerated by rehabilitation measures (Photo G-13). The amount of vegetation disturbance and removal is directly related to the surface area involved. Terrain and soils are variable and have the most effect on areas disturbed for well sites and roads.

The only damage noted to vegetation from steam discharge was where a vent discharge was directly released under a maple tree. About one-tenth of the tree had dead canopy limbs. It is assumed that the degradation was caused by chemical fumes and heat. A few bare areas are located around the original geysers and one can assume that a release of steam over a long period on a small area could have similar results (Photo G-14).

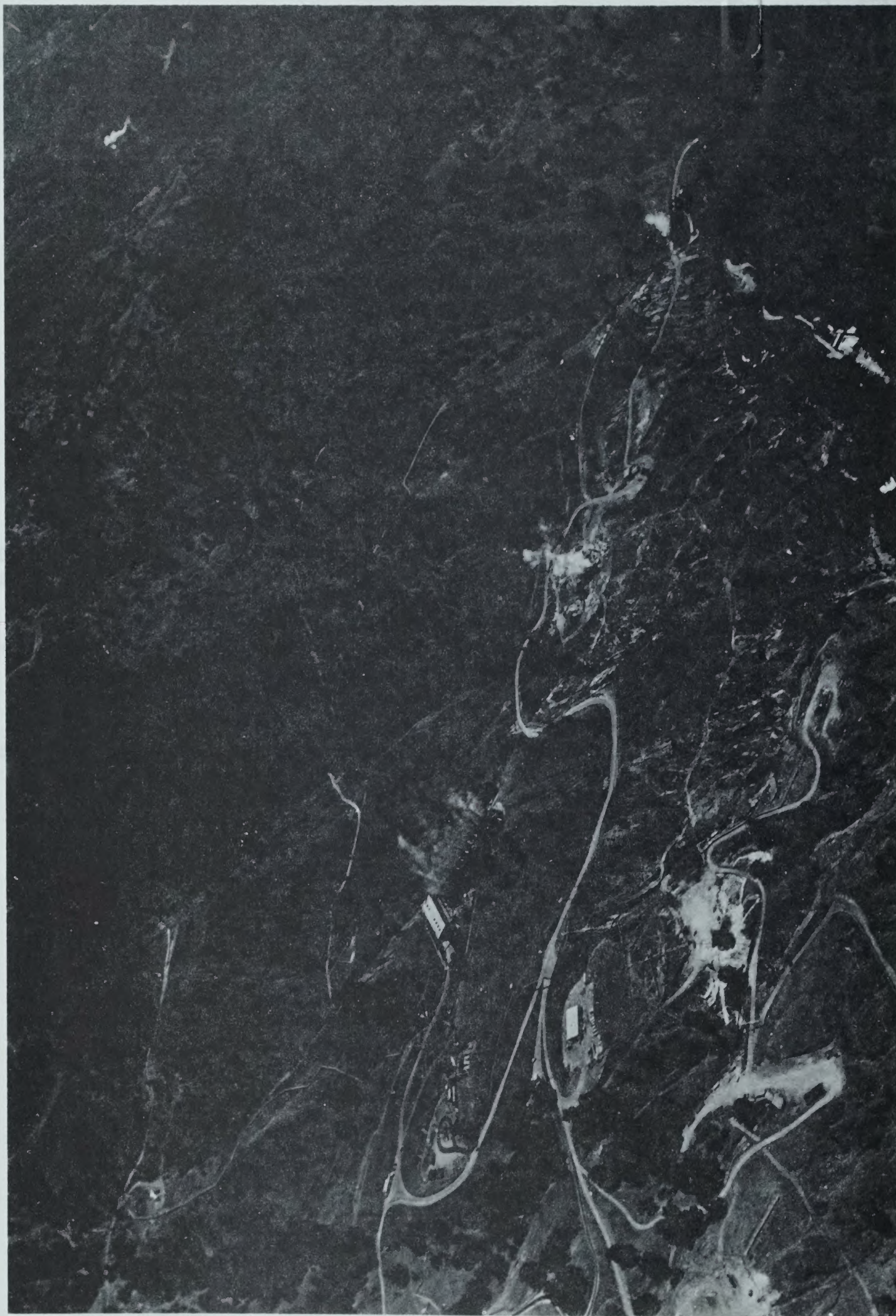


Photo G-12 - Oblique - photo of geothermal production area

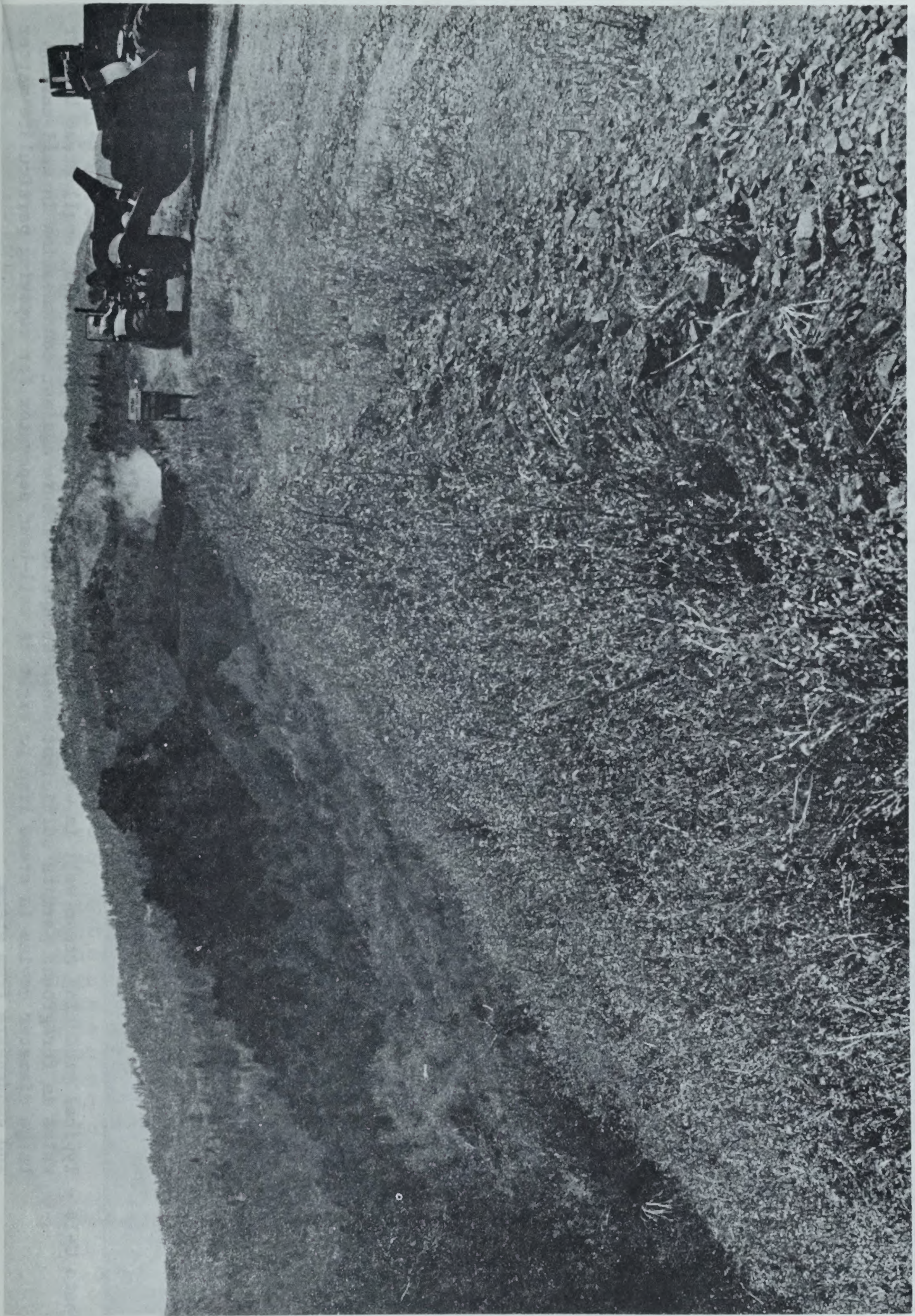


Photo G-13 - Vegetation cover provided by introduced rye and brome grasses

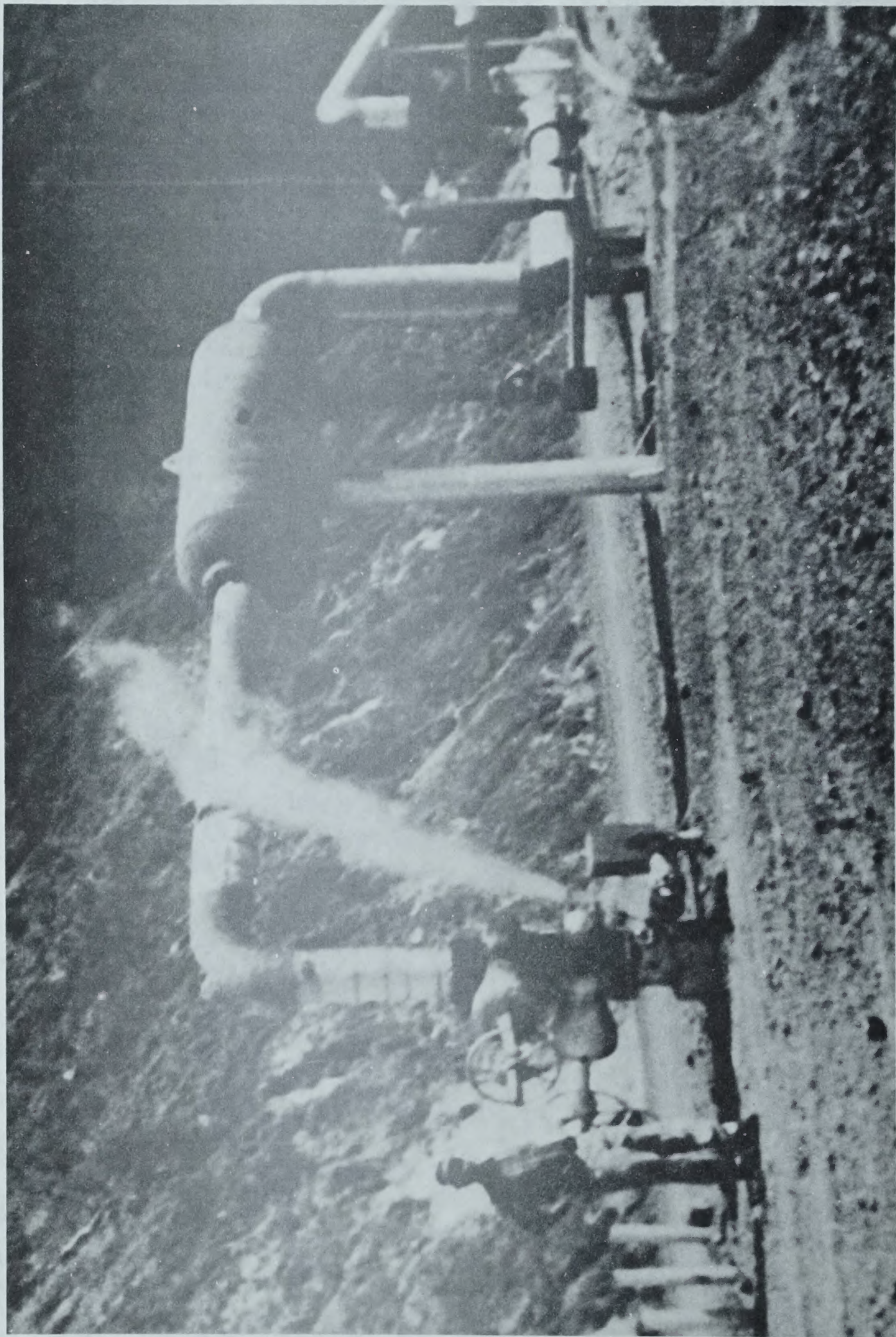


Photo G-14 - Typical producing steam well in Geysers Field. When well is not in production, small steam bleeder valve in foreground permits sufficient steam escape to insure against condensation in well casing. Large diameter device in steam line to right is well-head separator for removing particulate matter and condensate from steam.

#### e. Fish and Wildlife

Test drilling and production testing of geothermal steam resources in The Geysers KGRA could have varied impacts upon fish and wildlife. Most would occur on or adjacent to well sites, although water quality impacts could potentially have farther reaching influences. The magnitude of particular impacts would depend upon the extent and duration of the overall geothermal development activities and the effectiveness of impact control measures.

As a specific development proceeds through test drilling and production testing, physical land modification and commotion would occur. These activities would include such things as construction of roads, ponds, drill pads and drilling of wells. This could result in loss of wildlife values, including both habitat and human use within the area of influence. The land modification could physically alter or remove existing wildlife habitat, and permanence of these effects would be dependent upon the size of the area involved, the nature of the particular construction or operational activity, and the adequacy and completeness of control measures. In some instances, the revegetated areas could provide better habitat for some species than previously existed. In addition to land modification, the noise and human activity could have displacement effects upon animals in the site vicinity. The degree and permanence of displacement or disturbance likewise would depend upon the scope and type of activity. For example, although the effect on wildlife has not been completely evaluated, noise from testing wells could predictably have a disturbing influence upon some animals within the site vicinity.

Most areas adjacent to drilling and test operations, but outside of the immediate zones of physical modification and noise, would retain most or all of their fish and wildlife populations and habitat. Where existing public access to these areas would be restricted in order to reduce hazards to the public or damage geothermal equipment or improvements, there would be an accompanying reducing of hunting, angling, and camping opportunity on these lands.

Potentially significant impacts upon fish and wildlife could result from improperly planned or executed handling of geothermal fluids. If uncontrolled releases, spills, seepage or well blowouts were to result in significant additions of toxic geothermal waters to the drainages, adverse impacts would result. The fishery of the area could be the most severely affected. The existing Geysers operation at one time added fluids containing boron and ammonia to Big Sulphur Creek, resulting in adverse impacts on aquatic life. This practice has been stopped. Heated effluents could alter aquatic habitat and life, perhaps creating temperatures intolerable to existing fish species and over a prolonged period stimulating nuisance algae growth.

The toxic elements held in the sump ponds and the use of creek waters for drilling purposes are additional threats, especially to fish. Many ponds are built on hillsides having slopes from 40 to 60 percent. A dam failure could result in the toxic pond waters reaching the stream below (see photo G-15). Any amount of water diverted or pumped from the streams during the low flow period of late summer could have adverse effects upon fish life and depending upon the amount involved relative to total stream flow, could destroy the fisheries.

Erosion from roads and construction activities could result in added siltation of aquatic habitat within the area of project influence. Siltation probably would be most severe during construction phases, although some could also extend into the operational stages. Siltation effects could include coverage of fish spawning and feeding areas and shallowing of streams. The degree of damage to aquatic habitat would, to a large extent, be dependent upon the success of erosion control measures.

#### f. Seismic Hazards

Seismic hazards associated with test drilling are minimal. A potential hazard, however, could be created if a test hole should cross an active fault. Offset on the fault during an earthquake could sever the well resulting in loss of the hole and possibly a blowout with related environmental consequences.

Production testing should not pose a significant seismic hazard provided the transfer of fluids or gases is limited to small volumes.

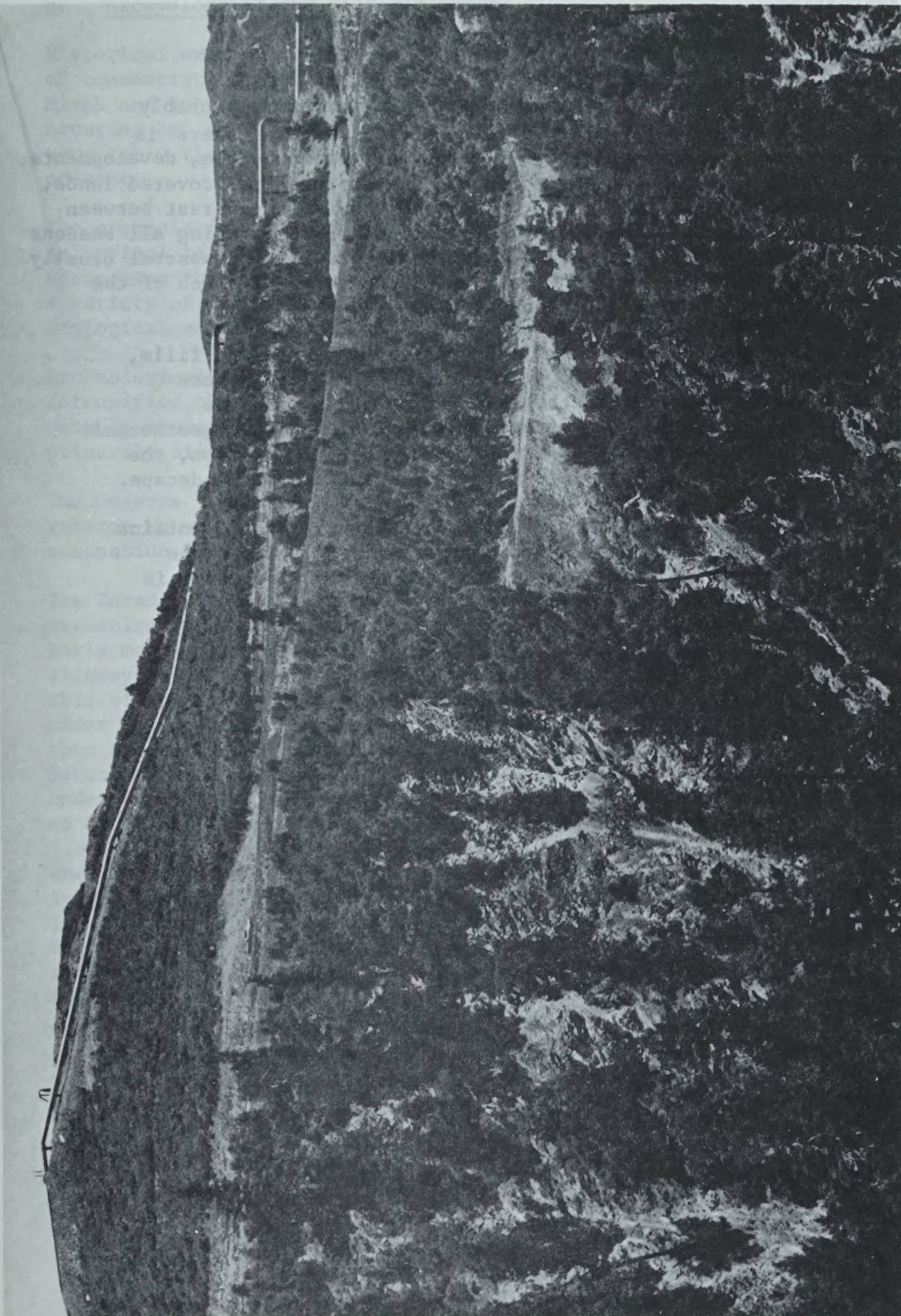


Photo G-15 - Sump pond constructed on steep slope. Note natural slip area immediately left of pond

g. Aesthetics

(1) Scenic Values

The scenic impact of test drilling and production testing probably would be different on each site tested. Within the KGRA there is considerable variety in topography, vegetation, public access, developments, soil color, etc. If vegetation is removed on the chaparral covered lands, the scenic quality will be reduced. There is a visible contrast between the dark vegetation and the light-colored soils, visible during all seasons because most of the brush species are not deciduous. The chaparral usually is found on the higher elevations in mountainous terrain. Much of the higher country is roadless and inaccessible.

Road and drill pad construction will require larger cuts and fills, thereby exposing more soil than would be exposed on less severe topography. Mount Konocti and the Mayacmas Mountain Zone are examples of two areas that would receive scenic damage from geothermal test drilling. Even though test drilling is of short duration, the necessary roads and drill pads are permanent scars on the landscape.

The scenic quality of the timbered areas on Cobb and Boggs Mountains would be less impacted by geothermal test drilling. Besides the screening effect of the trees, roads are more numerous so there is less need for new ones.

The generally flat terrain near Clear Lake and the valley bottoms near Kelseyville and Middletown would be the least impacted by exploration. Existing roads could be used. Extensive cut and fill work for the drill pads is not needed. The presence of the drilling tower is of short duration. After the drilling is completed the well head is not conspicuous.

#### h. Archeological and Historic Values

Historical evidence marks The Geysers KGRA as an important area of concentration with cultural trait exchange between Pomo, Wintun, Miwok and Yokuts peoples from quite early times. The naturally occurring hot springs were a focal point of aboriginal activity from very early times. Associated sites, therefore, are expected to be present.

The archeological historic environment of the Clear Lake Geyser KGRA is typical in pattern to California cultural resources with human occupation throughout, even from prehistoric times which indicate a variety of peoples habitating side-by-side in highly differentiated ecological zones and with a wide cultural variance.

Archeological field work within the KGRA itself has been less intensified than in many other sectors of central California. However, notable investigation by professional prehistorians have taken place, primarily since 1934, with varying degrees of intensification.

The Geysers KGRA is located within the California archaeological subarea known as the lower North Coast Range. Precolumbian human occupation sites are known to have been medium to high in density.

The Borax Lake site northeast of Bald Mountain in Lake County is an archeological site which has continued to pose problems concerning early man in the new world as it presents a complex pattern of human lifeways in this sector of California. Cultural deposits found at this site indicate Early Man sites in the vicinity of 10,000 B.C. and older exist within the general area. Man was present exploiting the then existing diversified environmental resources to their fullest potential as a gatherer and hunter. At later dates the area was under an even greater assault for its sustaining subsistence yield to other cultural complexes up to the late eighteenth century.

Geothermal resource exploration and development activities could result in the loss or destruction of scientific data that could be of importance in the reconstruction of California prehistory as well as New World history. However, if appropriate attention is given to archaeological and historic values, such activities could result in findings that might be of significant value.

## i. Recreation

During test drilling and production testing there would be an impact on the landscape and its component parts which contribute to outdoor recreation, namely: vegetation, wildlife, water, wildlife habitats, scenic views, and general aesthetics of clean air and quietness. The degree of impact on an area will depend upon the extent and combination of each of the attendant parts. In areas where natural fumeroles are present, a test well's plume of steam, noise, and  $H_2S$  aroma would not be greatly noticed. In a forested area, a venting test well is not visible, but the noise and odor attest to its presence. The impact of the drilling usually lasts only a few months. The testing and continuous bleeding of the well will last until the steam is utilized at a generator. The noise and smell will then be controlled. Most recreation uses will be adversely affected in the immediate vicinity of the test wells. New roads required to give access to the test wells could eventually improve recreation access, particularly for hunting, fishing, and rock hounding. However, in most cases, access to developed areas would initially be restricted in order to minimize vandalism and to ensure the safety of the public.

j. Mishap

The principal forms of unplanned environmental impact which may be encountered in drilling and production testing include blowouts, forest and brush fires, and landslides.

In any drilling into steam-pressured zones, such as a geothermal reservoir, there is a hazard of uncontrolled release of pressurized fluid. The hazard is greatest during reconnaissance and test drilling. Unforeseen conditions led to a blowout of Thermal well No. 4 during drilling near The Geysers Resort in 1957. Several attempts to control the flow of steam were unsuccessful, and steam is still escaping from several small vents around the well. The flow has diminished in recent years, probably because the pressure in the shallow steam reservoir is declining. Thermal well No. 5 also blew out but was soon controlled.

Both of the wells that blew out were drilled into the shallow steam reservoir which had the unusually high pressure of about 270 psi at a depth of 100 feet. (Hydrostatic pressure would be about 44 psi at this depth.) They were located in an area where the formations had been highly altered by exposure to geothermal fluids. The altered shallow formations were a soft, incompetent rock that would not hold the pressure of the steam reservoir once penetrated by the well. The State of California, Division of Oil and Gas, was given regulatory powers over the location and drilling of geothermal wells in 1965. No permits have been issued since that time for drilling in this localized area of altered formations, and no blowouts have occurred that can be attributed to this condition.

The forest and brush fire hazard is increased due to the greater level of human activity and traffic associated with the development. The brush fire hazard normally is severe in The Geysers area during the June-October dry season.

Another potential hazard of geothermal development in The Geysers area is that of landslides. Drilling and production do not cause landslides; however, landslides can seriously hamper operations and could conceivably result in casing rupture with a resulting uncontrolled escape of steam. The Yorkville soils underlain by the Franciscan series are the most susceptible. Landslides are most likely to occur during wet weather when increasing hydrostatic pressure increases instability.

Road construction and well site preparation, especially where large cut or fill areas are involved, also produce potential landslide areas. Such soil movement can cause damage to adjacent areas and to aquatic life in nearby streams.

Dam failure in sump ponds is a potential threat to fish and other stream life.

### 3. Field Development, Power Plant and Power Line Construction, Energy Generation, and By-Product Facilities

Once a geothermal field has been tested and proved to have economic value for commercial development, the potential environmental impact intensifies and, in some aspects, changes. Some activities, such as drilling and testing, continue for many years and their impacts may multiply. A whole spectrum of new activities is introduced with the decision to use the resource commercially. Additional wells are required to develop and use the resource most efficiently. Steam lines are constructed to convey the steam to the power plant. Power plants and cooling systems are built for electricity generation, and power lines must be erected to transmit the energy to the point of use. The lands would be committed to such use for a period of 30-50 years or more. (Photo G-16)

#### a. Surface Effects (Photos G-17 to G-20)

In The Geysers KGRA the increased surface impact accompanying full-scale electric power development has been largely a scaling factor. Additional fill-in-wells have been drilled, necessitating proportionally more cut and fill work on roads and well locations and the construction of a power site. The first power plant began operation in 1960. As of spring 1973, four plants were in operation, two others were under construction and environmental analysis made on an additional proposed plant. Mainline roads leading to the power plants have been paved with asphalt. Surface steam lines of 10 to 30 inch fiberglass and asbestos insulated pipe, with characteristically large U-shaped expansion loops, connect the wells to the power plant (Photo G-20). The greatest distance of any connected well from the power plant is 2,000 feet in a straight line in order to minimize pressure and temperature drop in transit. With this constraint, the first three power plants were built within one mile of The Geysers Resort in Sec. 13, T. 11 N., R. 9 W., and Sec. 18, T. 11 N., R. 8 W. A fourth plant (Photo G-18) is now operational and is located near the southwest corner of Sec. 7, T. 11 N., R. 8 W., about one-half mile from the nearest plant. Each plant is served by many producing wells. Thus, in the producing area, the terrain is laced with steam pipes, fuel breaks, connected together by high voltage transmission lines. The fuel breaks consist of areas cleared of brush and converted to grass-vegetative cover for approximately twenty feet on each side of the steam line (Photo G-20). This minimizes the damage to the steam lines in case of fires.

Each power area development disturbs 7 to 10% of the gross area involved. It appears that 800 to 1,000 acres are needed for each area. This acreage figure will probably diminish as more power plants are developed. The disturbed areas are broken approximately as follows: well site pads and work area - 3 1/2%, power house and cooling unit - 3/4%, mainline road - 1 1/2%, steamlines, access roads - 2%.

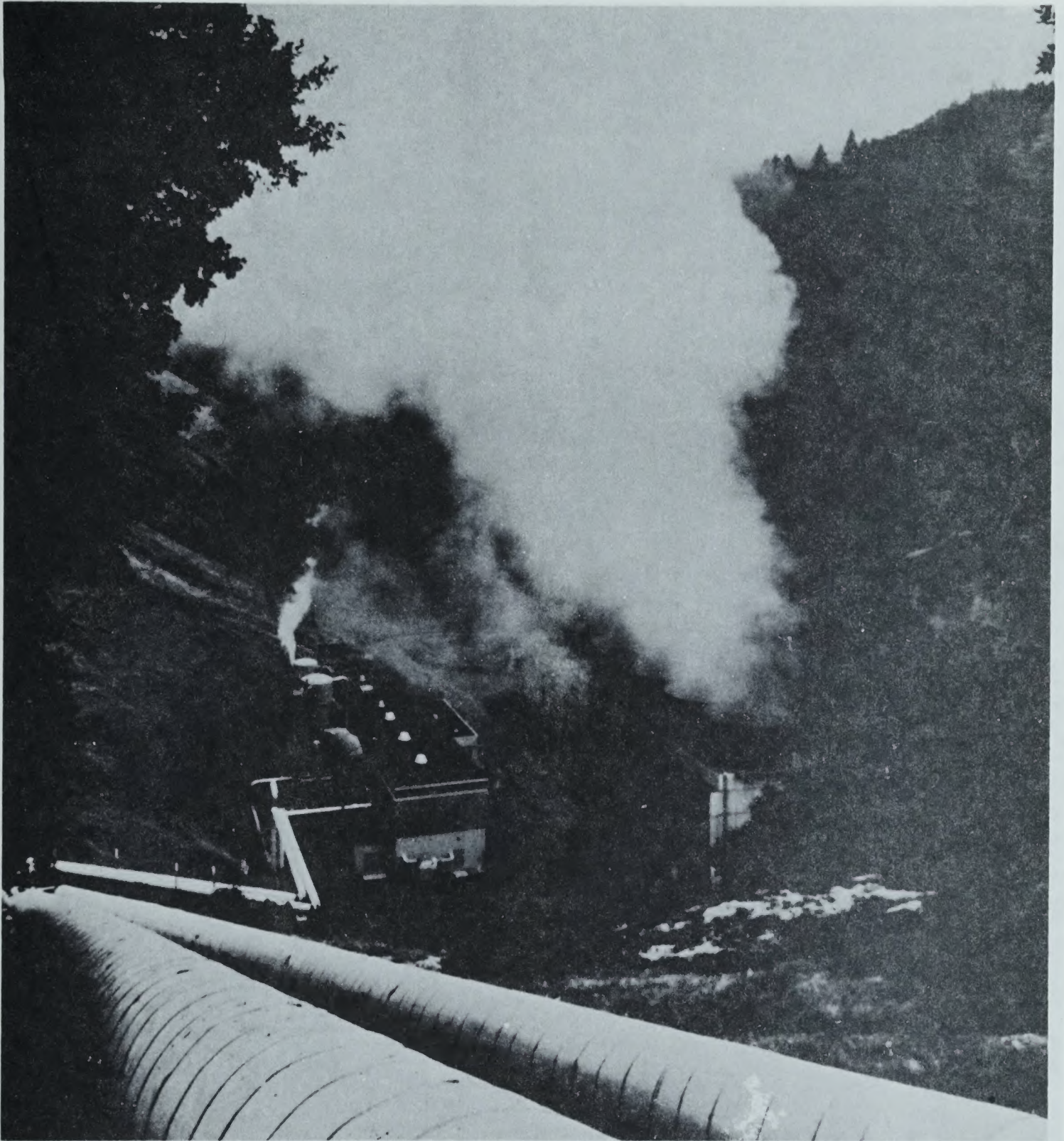


Photo G-16 - PG&E units 1 and 2, Geysers Geothermal Power Plant, Sonoma County, California. Generating Station center, forced draft cooling towers on right. Insulated steam lines in foreground.

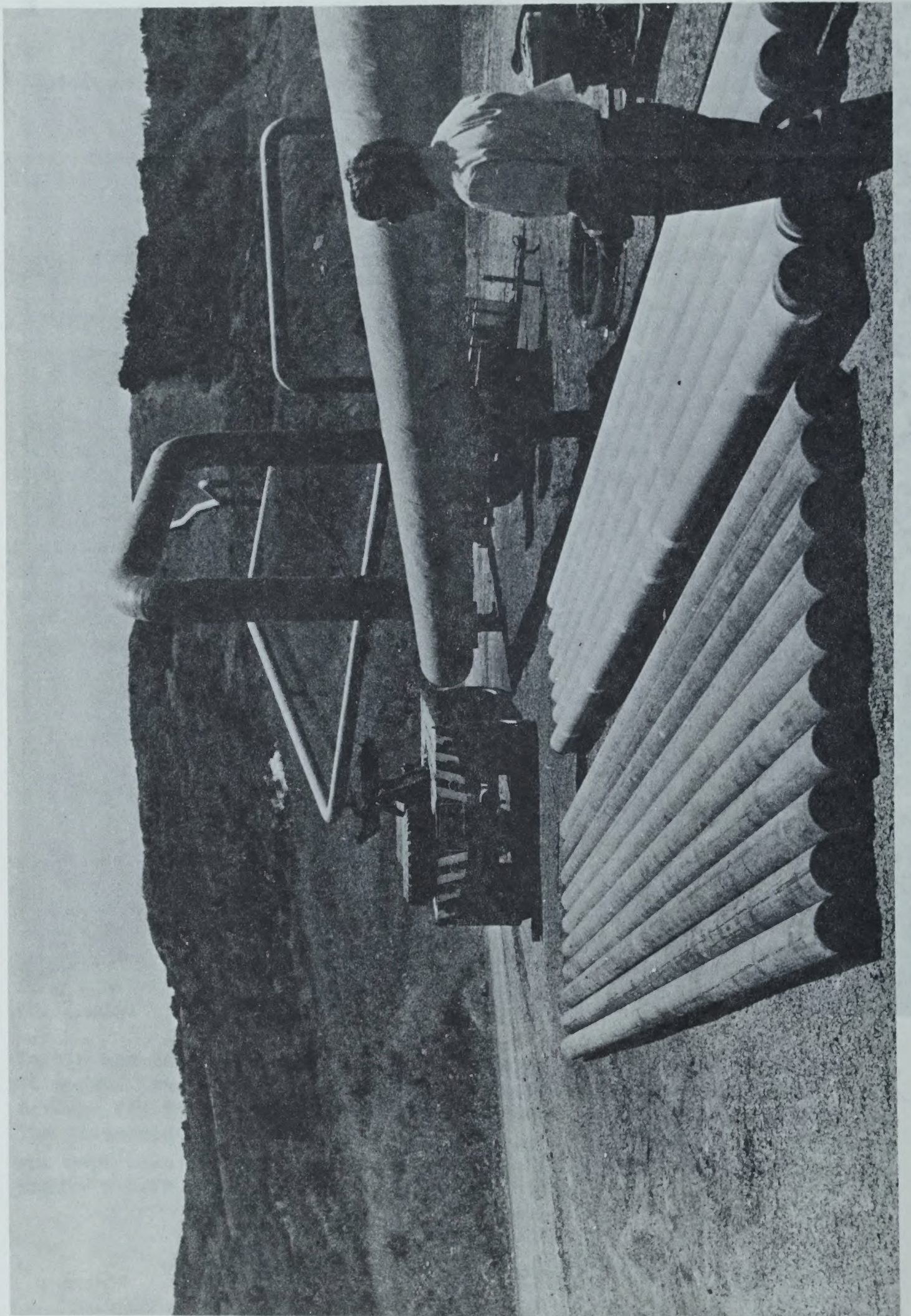


Photo G-17 - Steam lines, expansion joints and work area

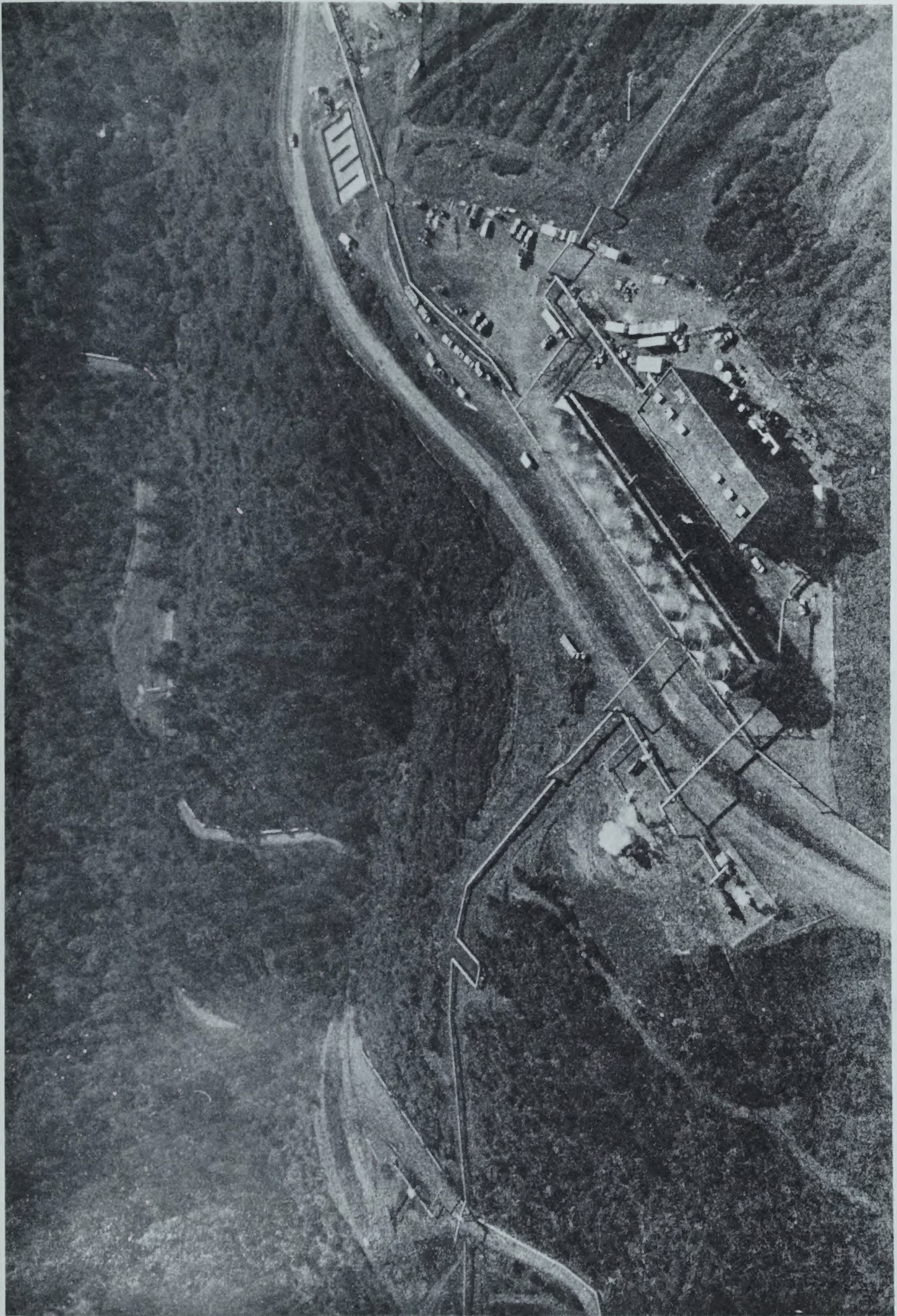


Photo G-18 - Power house No. 4, Units 7 and 8

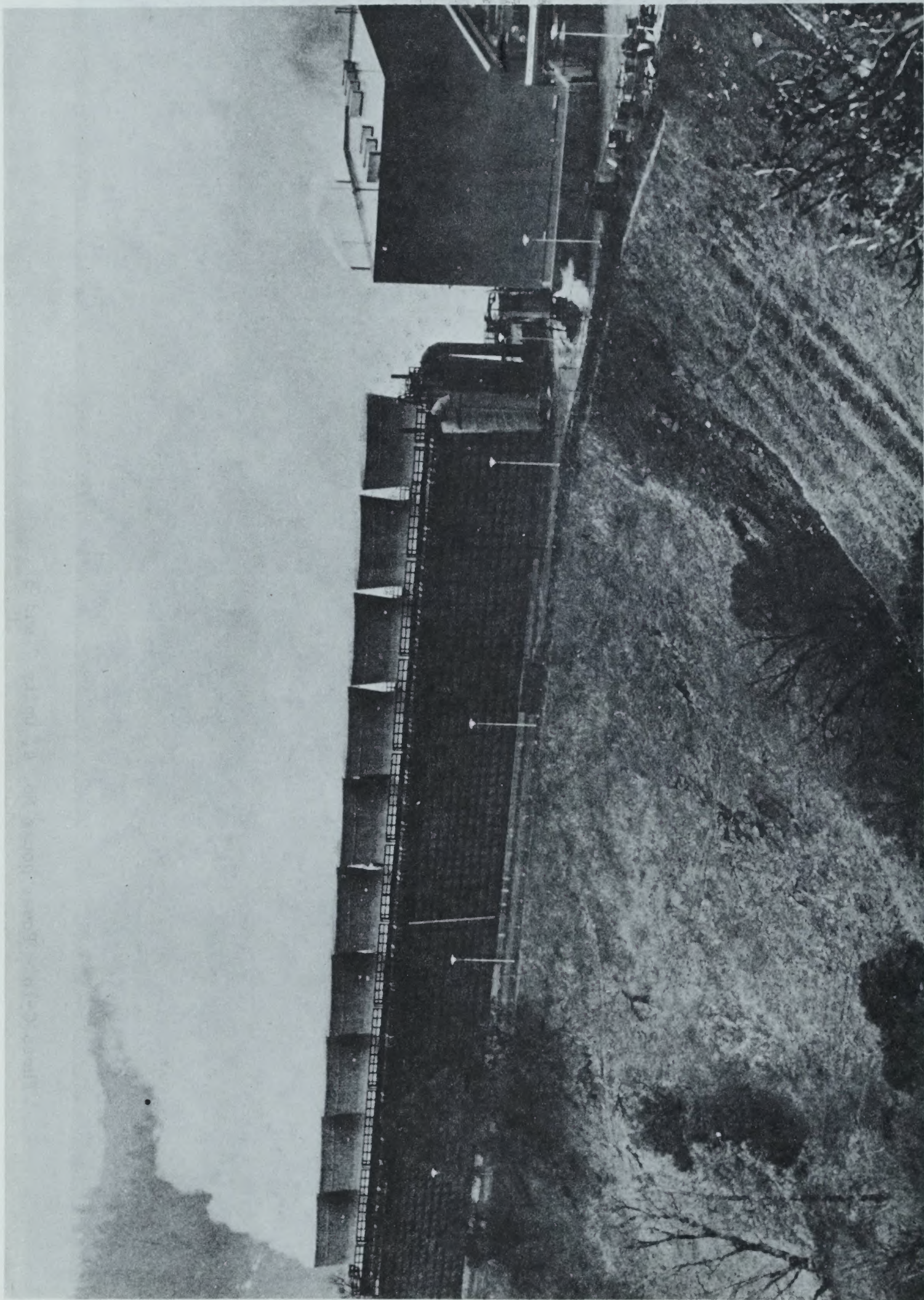


Photo G-19 - Cooling towers and generator plant at Pacific Gas and Electric Company's Units 5 and 6, Geysers Geothermal Power Plant, Sonoma County, California

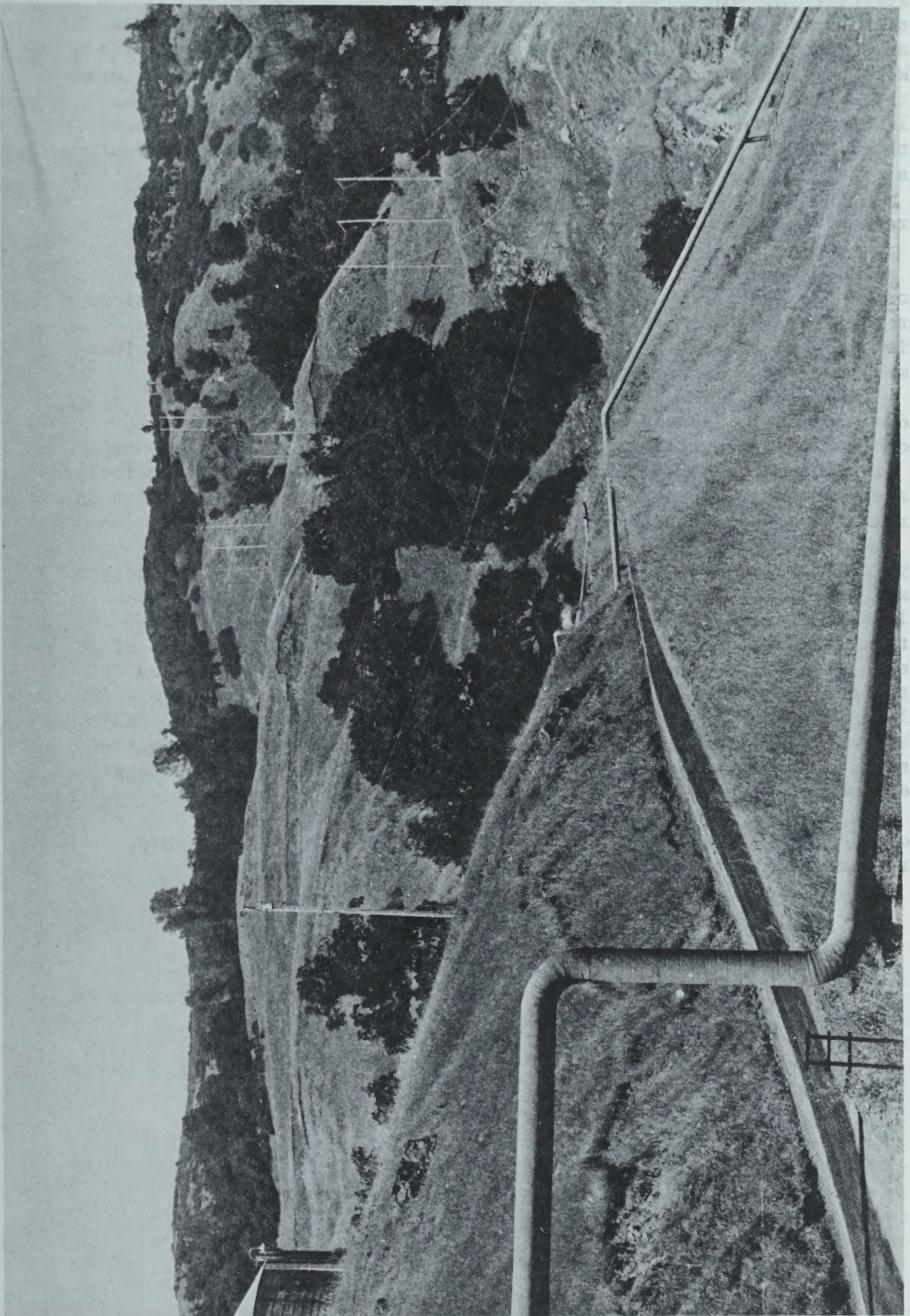


Photo G-20 - Mainline road, steam lines and fuel breaks - good establishment of ground cover on the fuel break

Construction of roads, well and powerhouse sites is the principal physical surface impact, and can be significant in The Geysers KGRA because the steep terrain (30-70% slopes) requires major cut and fill work. Level areas for drilling are almost nonexistent. Generally one to three acres of cut and fill is required to provide room for the drilling operation (Photo G-8). A mainline road disturbs an average width of 50 feet, and a secondary road disturbs approximately 30 feet. This includes from top of cut to bottom of fill. Pipeline construction and maintenance of a low volume fuel fire hazard area occupies an average width of 40 feet.

The areas shown in photographs G-20 are relatively stable soils (Los Gatos and Maymen). The highly unstable soils occur lower on the slope near the drainage bottoms (Photo G-21). The soil is the Yorkville series, has poor slope stability, and usually produces the high volume of sediment found in the drainages.

Road maintenance will vary for each soil type. Increased sediment production will occur following initial construction and decrease as the disturbed areas restabilize. The sediment problem can be ameliorated to a considerable degree by buffer strips between the disturbed area and a drainage and by adequate slope disturbed area treatment.

A typical power plant at The Geysers consists of two turbine generators housed in a single building with an adjoining structure housing the cooling towers (Photo G-18). The newer plants consist of two 55-MW units in each plant. The second power plant built (Units 3 and 4 of 28 MW each) is housed in a building 140 feet long by 34 feet wide and 30 feet high. Adjoining is a cooling unit consisting of three 36' by 66' cells of counter flow induced-draft type. The tower is sheathed and decked with 3/8 inch flat cement asbestos board for protection against brush fire damage. A switch yard, storage building and high voltage lines complete each unit.

A normal 110 MW power plant uses about 2,000,000 pounds of steam per hour which will require from 15 to 25 producing wells.



Photo G-21 - The Geysers and Power Plants 2 and 3. Slide prone Yorkville soils and a woodland-grass vegetative cover

## b. Water Resources

The impact of production-scale electric power development on water resources is similar to that of the drilling and testing phase, but on a more extensive scale. Steam production to date has not had a noticeable effect on ground water resource, although a reduction in flow and perhaps a change in temperature and/or chemical character of thermal springs in the area may eventually result from extensive steam production.

Evaporation of geothermal steam condensate in the condenser cooling process at The Geysers averages about 45 acre/feet per year per megawatt of plant capacity. This amounts to a consumption of about 8,000 acre/feet in 1972, chargeable to the deep subsurface water budget of the local drainage basins and would be commensurably increased as the field is expanded.

The impact on surface streams will continue to be mainly in the form of increased sediment yield stemming from clearing and grading operations. As more roads and well sites are constructed, new areas will be affected. The early geothermal development was confined to the basin of Squaw Creek to the north, and is programmed for Kelsey and Anderson Creeks to the north and west. The increase in the number of new wells could pose a problem relating to late summer water flows and to fish life. Water for the drilling is taken from adjacent streams. As explained in the fish and wildlife resource section, any decrease in late summer steam flows could be detrimental to fish.

The threat of drilling mud and associated chemicals escaping from the sump ponds into nearby streams poses a potential stream water quality problem. Many of the ponds would be constructed on 40 to 60 percent slopes and within one quarter mile of the bottom of the canyon. Once these ponds have dried, the drilling residues would be covered with the loose dam fill soil. It is not known what may happen to these chemicals during the following winter rainfall periods. One of the well drilling detergents commonly used is Magcobar Foam 44 which has a lethal toxicity to fingerling trout at 10 ppm.

The Union Oil Company has established two water quality monitoring stations on Big Sulphur Creek. One is just upstream from P.G. & E. Power Units 1 and 2 and the other just upstream from the mouth of Squaw Creek. Monthly monitoring has occurred since May 1968. In several instances it appears that well drilling and related activities were the cause for raised levels of suspended materials and increased nitrogen levels. The findings are not conclusive, as natural slides and mineral springs are additional sources for these pollutants.

As the Geysers power plants, approximately 80 percent of the steam is used for condenser cooling. The remaining 20 percent, containing natural contaminants, principally ammonium biocarbonate ( $\text{NH}_3\text{HCO}_3$ ) and chemicals added to the cooling water, must be disposed of. For the past 2 1/2 years all such waste water has been reinjected under gravity head

into nonproducing wells without difficulty. The average injection rate is currently (1973) about 900 gallons per minute. In view of the success of this disposal technique, the operators of the field plan to use similar disposal wells for all plant waste water disposal. Both the steam and steam condensate at The Geysers are corrosive to some metals. Therefore, construction materials must be selected for each corrosion environment that occurs. Minor leaks could occur due to corrosion, but should not result in any special hazards.

c. Air

(1) Noise

Noise from a fully developed, power producing steam field like The Geysers is relatively modest. Like other industrial areas, there will be the transportation of men and materials through the area, and maintenance of buildings, equipment, and roads. Noise associated with The Geysers is the occasional venting from wells through mufflers and occasional pipeline leaks. Major pipeline breaks could create loud noise for a short time until valves could be activated to reduce the flow and vent through the well muffler system.

The noise associated with well drilling and testing during field development could be the same as described under test drilling and production testing only on a much larger scale. In a relatively small area, instead of one well being drilled there may be several; instead of one venting well, there may be ten or 12 venting.

The construction of power generating units increases the daytime ambient noise level from about 56 to 64 decibels (dbA) to the 75 to 80 dbA range. Certain construction activities cause occasional noise levels in excess of 90 dbA, but these are of short duration. When the power plants are in operation the largest single source of noise is the jet gas ejectors. Unattenuated noise levels from this equipment are in excess of 117 dbA with peak frequencies in the 2,000 to 4,000 hertz octave bands. Using path treatment (involving the use of accoustical insulation on noise-radiating equipment), noise is reduced to 84 decibels in the 2,000 to 4,000 hertz octave bands. Fans in the cooling towers create noise but this is confined by the structure to the immediate vicinity of the plant. There are no residential areas within close proximity to the developed geothermal area as shown on Map G-5.

(2) Gaseous Emissions

Gaseous emissions to the atmosphere were discussed under test drilling and production testing. During field development for a generating plant, gaseous emissions increase. Instead of one test well venting, there will be several wells emitting steam and noncondensable gases into the atmosphere. At the wellhead there is no attempt to control or remove the noncondensable gases.

When the steam is transported and consolidated at the generating plant control of the noncondensable gases is attempted (see Table G-9). The nuisance odor and toxicity of hydrogen sulfide at The Geysers arouses the most interest. Standards for operating personnel set by the Occupational Safety and Health Administration place the ceiling value, which should not be exceeded during a normal 8-hour day, at 20 parts per million. Concentrations in the immediate vicinity of existing generating units at The Geysers have been measured in the range of 5 to 10 parts per million. On one occasion, during the startup of Unit 7, a concentration above 20 parts per million was measured in the working area of the plant. This condition was rectified before normal operations of Unit 7 began by providing extensions to the discharge vents for the offgas ejectors. The California Air Resources Board established 0.03 ppm as the unpleasant odor threshold of hydrogen sulfide. A more complete description of gaseous emissions is in Volume I, Chapter III of this environmental statement.

Table G-9  
Noncondensable Gases Identified in Steam  
from Wells at The Geysers Power Plant

	<u>Range of Concentrations Measured</u> <u>Percent by Weight</u>	
	<u>LOW</u>	<u>HIGH</u>
Carbon dioxide	0.0884	1.90
Hydrogen sulfide	0.0005	0.160*
Methane	0.0056	0.132
Ammonia	0.0056	0.106
Nitrogen	0.0016	0.0638
Hydrogen	0.0018	0.0190
Ethane	<u>0.0003</u>	<u>0.0019</u>
Total noncondensibles	0.120	2.19

\*Overall average from steam in headers at Units 1-4 during the period 1968-70 was 0.0461%.

#### d. Vegetation

Drilling of test and production wells, construction of power units, pipelines, maintenance areas, and roads on federal lands will involve controlled clearing and leveling of ground and will result in both the permanent and temporary destruction of the native plant life on those areas. On the average, about 8 percent of a production complex area is disturbed. In the steep terrain areas, it takes approximately 800 acres for a production unit and about 80 acres are disturbed. The production complex consists of well sites, roads, pipelines, power house, cooling unit, and maintenance areas.

The access roads, rocky cuts, power house, cooling unit and maintenance-storage areas will result in destruction of the native plant life on those sites. Areas on each side of the steam pipelines will be converted from chaparral to grassland. This is necessary because of the fire hazard to the pipeline if the native brush were allowed to reestablish. Some of the cuts and most of the fills on roads, well pads, and power plant areas will revert back to a combination of grass and native chaparral.

The recoverability of vegetative cover on disturbed areas varies by species, soils, and severity of disturbance. Most of the area has at some time been burned over as a result of forest fires or controlled burning. Burning has a very short term impact on the woodland-grass type. The grass and forbs seed supplies in the soil are ample and fall rains induce germination almost immediately. Road cuts and fills react similarly to burning, except the seed supply is transported to the disturbed area by wind and gravity. Recovery of vegetative cover normally takes two to three years except on steep rocky cuts where most of the soil has been removed (Photo G-22).

Burning of the chaparral also has a short term impact on the vegetation. Most chaparral species are fire climax and sprout readily from the burned crown. The recovery of the original ground cover density usually takes from three to eight years, depending on the site. The reinvasion of chaparral species on disturbed areas usually is a long-term process. This results from two factors: (1) the heavier brush seed doesn't move far from its original site because of its large size, and (2) the open, disturbed areas attract a variety of animal life that forage on the tender brush seedlings that do germinate. On some of the better sites, vegetative cover will establish in 5 to 10 years. Poorer sites have taken as long as 20 years to naturally revegetate. A more complete discussion of environmental impacts of vegetation may be found in Volume I, Chapter II, Section D, and Chapter III, Section B, of the General Statement.

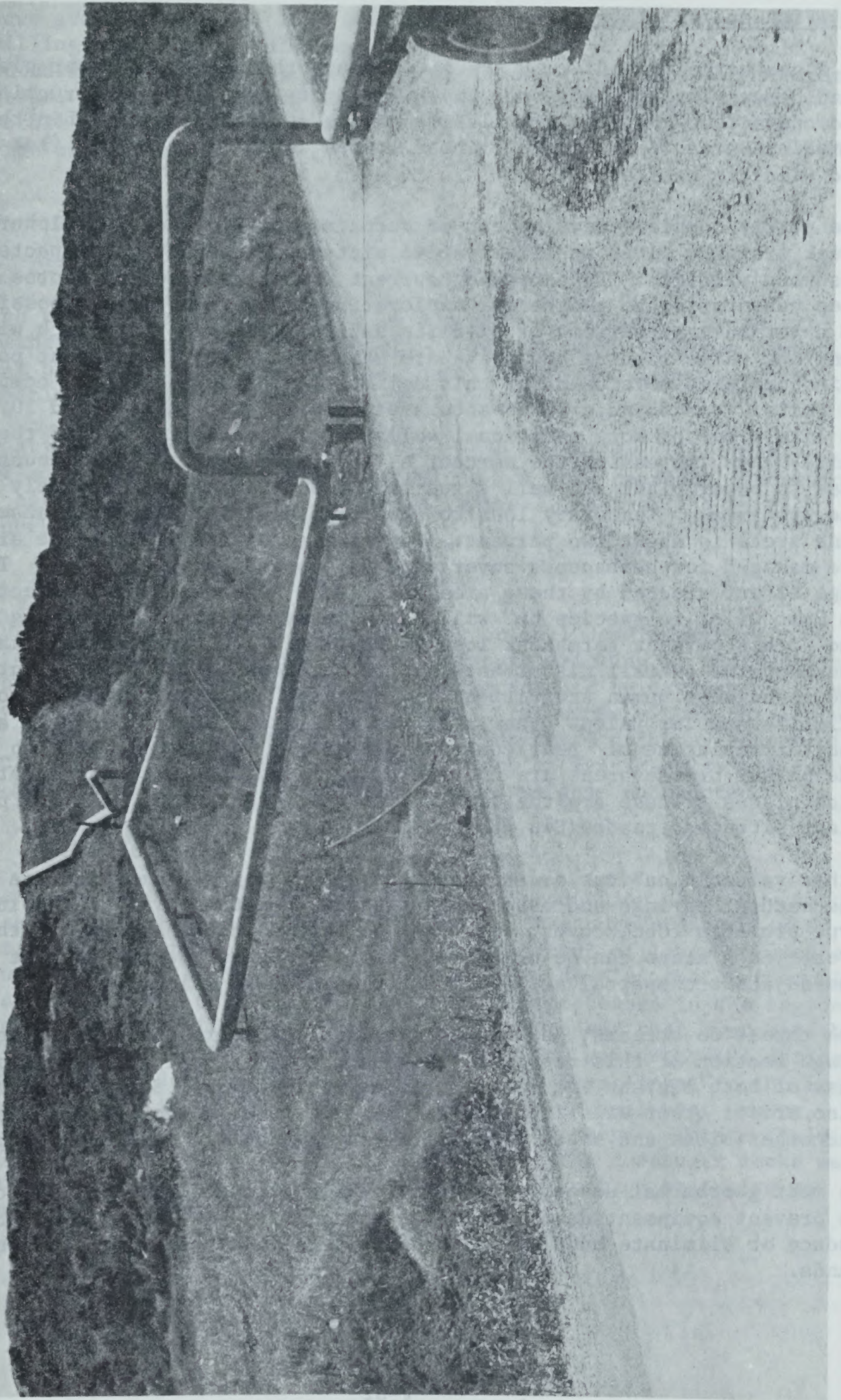


Photo G-22 - Recoverability of woodland-grass vegetative cover following disturbance by road construction

e. Fish and Wildlife

As a geothermal field would proceed through the stages of power plant, road, transmission lines, and any by-product facilities construction and operation, the loss of wildlife values could continue within the immediate area of influence. These losses could include both fish and wildlife habitat.

The nearly complete development of certain areas in the Big Sulphur Creek drainage gives an illustrative picture of the natural impacts on fish and wildlife. By comparing current (June 1973) aerial photos to ones taken prior to geothermal exploration activities, it was possible to determine the percent of wildlife habitat loss and that which will continue to be lost as new areas are developed. Two independent power unit complexes were used for this delineation: a 932-acre area comprised of Units 7 and 8 and a 1,036-acre area comprised of Units 9 and 10. It is likely one or more additional wells will be added to each of these units, thus increasing the percent of destroyed habitat. Permanent loss to power plant and well sites is 6 and 5 percent respectively for the two areas. Temporary loss to sump pond and pipeline and transmission line areas is about two percent. Pipeline and transmission line areas are managed for herbaceous cover type as opposed to shrub cover. The edge effect created by these areas will have some beneficial effects to most wildlife species but will have little effect in offsetting the 5 to 6 percent permanent loss of habitat. The permanent habitat loss and the overall disturbance by the numerous wells, power plants, and associated human activities will decrease the populations of most wildlife species unless other measures are taken to provide comparable habitat replacement. Deer could be especially influenced, as much of the better browse areas are located along ridgetops and other relatively flat places. These are the first areas to be chosen for well and power plant sites and roads (See photo G-18).

Other valuable habitat areas that have been damaged or modified are the natural springs and associated riparian vegetation. This habitat type provides food, cover, and water to most wildlife species of the area. Such areas can be classified as "key" areas because without them the adjacent chaparral areas have little wildlife value.

The threat to streams, as pointed out in the resource reconnaissance stage section of this report, is high and could result in fisheries loss of both migrant and resident trout populations. Such a loss could also affect other wildlife such as the great blue heron, water ouzel, and other birds and small mammals relying on aquatic life for food.

In most geothermal development areas public access would be restricted to prevent equipment damage and as a human safety factor. This would reduce or eliminate hunting and other recreational activities on these lands.

Above ground obstacles such as transmission and phone lines and well drilling structures could cause some mortality to birds, possibly including eagles. The light drilling towers could pose a particular threat, especially during the spring and fall migration periods. Overall loss is not expected to have any detrimental effects on avian populations.

f. Aesthetics

With the further development of a production industry, the natural aesthetic values will be modified. Numerous roads, surface pipes, well pads, generating facilities, and transmission lines will be visible and detract from the natural setting.

Creation of new roads could contribute to vandalism, littering, off-road vehicle and higher density use. A more complete discussion of aesthetic impact may be found in Volume I, Chapter III of the General Statement.

g. Archaeological and Historic Values

Any test wells, production activities, or full development will alter the terrain surface and could disturb existing or undiscovered archeological sites. Due to the steep grades to be excavated, cuts and fills will occur destroying cultural resources either totally or in part. When such disturbances occur, cultural data may become of minimal utility to science. However, such activities also may result in new discoveries that otherwise would have gone undetected.

h. Seismic Hazards

There could be seismic hazards during the production stage due to the risk of triggering earthquakes by changing the pore pressure in an active fault zone due to injection or withdrawal of large volumes of fluid. Although it is probably safe to fully develop the geothermal resources in The Geysers KGRA, the tectonic processes in the region are as yet not fully understood, and it is prudent that awareness be maintained as to the possibility of triggering an earthquake during some phase of development. Earthquakes have been linked to the injection of fluid in wells at the Rocky Mountain Arsenal near Denver, Colorado, and the Rangely oil field in northwestern Colorado (Raleigh, 1972). In both cases evidence suggests that the reservoir rocks were under substantial tectonic shear stress--a situation that also may exist in The Geysers KGRA.

In the Denver series, earthquakes with magnitudes up to 5 1/4 were triggered at distances of several KM from the base of the injection well (Healy, et. al., 1968). Earthquakes have also been triggered by the withdrawal of large volumes of fluid. In the case of the Wilmington Oil field near Long Beach, California, the earthquakes were apparently associated with large scale subsidence (Kovach and Archambeau, 1972).

The potential consequence of triggering a moderate earthquake during geothermal production could involve damage from intense shaking or landslides to nearby structures including the power plant, steam pipes, etc., and rupture of producing wells resulting in a blowout. The possibility of damage to the power plant and rupture of steam pipes from a naturally occurring earthquake in the vicinity of The Geysers KGRA must also be considered. The area is not densely populated or heavily developed. Earthquake damage outside of the operations area would depend upon the severity of the earthquake, the population of the area, and nature of improvements involved.

#### h. Social Effects

##### (1) Economics

The 1971 market value of geothermal steam produced in The Geysers area was \$5,040 per day. The value of the electricity produced was \$30,240 per day. By 1975, these figures are expected to increase to \$36,000 and \$126,000, respectively. During Fiscal Year 1970-71, the State of California expected to collect \$40,000 in royalties and rentals for state lands, with an increase to \$270,000 in Fiscal Year 1974-75.

In the vicinity of The Geysers, geothermal development has had a dramatic effect on land values. Much of the private land which is under lease would have a value of approximately \$100/acre if it had no geothermal potential. Sonoma County tax records indicate that one 234-acre parcel adjacent to The Geysers Resort has a land value of \$16,400 per acre. The tax on this parcel (excluding personal property and improvements) yields Sonoma County over \$93,000 per year. In Fiscal Year 1973-74, Sonoma County will receive about \$1,000,000 from the land, personal property, and improvement tax in the Geysers area. This does not include taxation of possessory interest in undeveloped leases. Sonoma County will soon begin taxing this source also. Lake County has not yet developed a taxation policy for geothermal development. It has indicated that it will do so in the near future and this policy may be expected to be similar to Sonoma County's.

The Federal government does not pay property tax. However, persons who hold leases to government lands are subject to taxation of the possessory interest value of that lease. It may be expected that the tax liability accruing to the lease holder will be similar to that which would accrue to the landowner if that landowner were a private individual. The tax revenue to the county from geothermal development will therefore

be approximately the same regardless of ownership. The value of leases on government land may be established by open competitive bidding. This price would probably establish a firm basis for possessory interest assessment, whereas leases on private property present much greater problems in assessment.

For Fiscal Year 1973-74, the geothermal development at The Geysers will provide about \$2,500 per megawatt of power production capacity as annual revenue to Sonoma County. Development on government land may be expected to be similar and hence yield comparable revenues for areas developed. At present, national resource lands are yielding little direct tax revenue to the counties.

Any harmful environmental effects resulting from geothermal development of government lands, may affect adjacent private lands which are not developed. Similarly, development of adjacent private lands could impact on Federal lands. The non-geothermal property value and tax revenues from the private land may then decline, but the net effect on county finances would probably remain positive.

In the few cases where government-owned mineral rights coincide with land use orchards, geothermal development could result in a decrease in local employment. On the greatest proportion of the lands being considered for government lease of geothermal rights there currently is no employment-producing use. Geothermal leasing would produce a positive employment impact on the bulk of the lands.

The existing generating facilities require five people per generating facility (110MW). The steam producing facilities (wells and pipeline) require five people per 100 MW produced plus 20 people drilling new wells to replace expired ones. This means employment of 10 people per 100 MW of power produced plus 20 people drilling replacement wells. People employed in the exploration and construction stages are not included in these statistics. At the present stage of development and operation there are 150 to 200 people employed at The Geysers site. This is a significant short-term contribution to employment in the vicinity.

The geothermal power facilities are also a potential tourist attraction. It is estimated that there will be 72 bus tours conducted to The Geysers site in 1973. Providing accommodations and services for visitors could provide additional employment in The Geysers KGRA and adjacent towns. This could compensate for any decline of the hot spring and mountain resort employment.

To the extent that geothermal development conflicts with cinnabar mining there could be a loss of potential employment in mining. Since none of these mines are currently operating, and operate only sporadically, geothermal development could result in a net employment benefit but may redistribute income away from mine owners.

## (2) Population Distribution

The population distribution in the KGRA could be altered as a result of geothermal development on government lands. There may be some increase in population resulting from the employment opportunities.

The temporary influx would occur at the time of initial exploration and construction of power production facilities. People who have been employed in construction at the Geysers have usually resided at Cloverdale or Healdsburg. As a result, there has been very little increase in the number of people living in The Geysers area.

Since only about 10 people per 100 MW of power produced are required to operate the production facilities, very little change in population distribution would result from this source. An additional 20-man crew is currently employed at The Geysers drilling replacement wells. As the development enlarges, more crews may be employed. These people as permanent employees, may choose to live near their places of employment, increasing the population density in areas which are now almost unpopulated.

## (3) Transportation

Some increase in automobile traffic into The Geysers KGRA may be expected. Drilling and construction crews, supervisory personnel, state and federal employees, and others involved in various phases of development and power generation may increase traffic flows. No radical change in the existing transportation system would appear to be required. There may be some road widening and curve straightening on existing public roads. Because the area is largely mountainous, this construction could have a significant impact. Very little of the government land is accessible by public roads. The existing roads into and adjacent to these lands are generally inadequate for geothermal development. Improved roads would have to be constructed on the government lands at the time of development. These would eventually provide public access to areas which are presently inaccessible. Owners of private land adjacent to national resource land in this area may oppose public access to the national resource lands.

Though tourism would add to the traffic load, it is not expected to be so great as to require a higher road standard than the geothermal development itself. A more complete discussion of the impact of development on transportation is found in Volume I, Chapter III, Section B of the General Statement.

#### (4) Modification of Land Uses

The major land use conflict that may occur with geothermal development of the Geysers KGRA is with recreation uses such as hunting and camping. However, much of the federal land now is relatively inaccessible which limits such use. Recreation pressures could increase with improved access. This has been discussed under Fish and Wildlife and Aesthetic sections. Other recreation use conflicts could occur in the mountain resort area of Cobb Mountain. Conflicts would occur on agricultural lands, found mostly near Clear Lake. A more complete description of the modification of land may be found in Volume I, Chapter III, Section B of the General Statement.

#### (5) By-Product Industries

The establishment of by-product industries in conjunction with present geothermal steam development is not anticipated in The Geysers KGRA because the steam produced is fairly pure. While two-phase systems may eventually be found within the KGRA, geothermal brines should never be found in the KGRA. A more complete discussion of environmental impacts of by-product industries may be found in Volume I, Chapter III, Section B of the General Statement.

## j. Mishaps

The possibility of an uncontrolled blowout is always present when drilling into the steam reservoir. This possibility is reduced to a low risk by using modern drilling methods and the experience gained by drilling more than 100 wells in the field. Control of the wells in the deep reservoir can be assured by cementing the first string of casing through the shallow ground water zone and the shallow steam zone, if present, to a depth of about 2,000 feet. The present industry practice is to cement the second string of casing to a depth of about 4,000 feet in impermeable rock above the deep reservoir.

Movement of the earth could cause blowouts despite the use of good engineering practice either as landslides at shallow depths or slippage along deeper faults. The casing in Happy Jack well No. 7 was broken at a depth of about 35 feet following heavy rains in January 1973, and it is assumed that this was caused by a small landslide. To date the well is not under control. The noise and fumes are a constant reminder of its presence. Proper site selection may have prevented the mishap.

Only a small amount of subsidence is predicted at the Geysers. Studies of subsidence caused by withdrawal of water from aquifers, and oil and gas reservoirs, have shown that the extent of subsidence depends mostly upon three factors: the compressibility of the reservoir rock, the reduction of pressure in the reservoir, and the thickness of the producing formation. The hard graywacke in The Geysers deep reservoir is only slightly compressible. The reservoir pressure, about 480 psi, is much lower than the normal pressure in porous rocks at this depth. (Hydrostatic head at 5,000 feet would be more than 2,000 psi.) The thickness of the formation is not pertinent in this case because each foot of formation is essentially noncompressible. Since the conditions that cause subsidence are not present in The Geysers field, it seems unlikely that subsidence will be a problem. A more complete discussion on problems of subsidence may be found in Volume I, Chapter III, Section B of the General Statement.

Other potential mishaps such as wildfires, landslides, and sump pond dam failures are discussed in the Test Drilling and Production Testing section. All of these potentials become greater as development and human use activities increase.

Wildlife road kills are another potential hazard. Increased miles of road, improvement of roads that increase vehicle speed, and increased vehicle use all add to this hazard.

#### D. MITIGATING MEASURES INCLUDED IN THE PROPOSED ACTION

Mitigation of potential environmental problems and impacts stemming from all aspects of geothermal exploration and development activity in the Geysers KGRA will be accomplished through enforcement of applicable Federal, State, and local laws and regulations, geothermal exploration and leasing regulations, geothermal operating regulations, Geothermal Resources Operational (GRO) Orders, lease and land-use permit stipulations, and application of existing and developing and yet to be developed technologies. Some environmental impacts are known and can be prevented; some impacts can be anticipated and adequate environmental protection can be planned; some impacts can only be hypothesized so contingencies included under the general regulations provide a means for corrective action in the event these impacts become reality. If unacceptable environmental factors exist which can not be corrected, development or operation would not be permitted.

The Geysers area has the benefit of commercial development and production from private lands adjacent to comparable Federal lands. This experience provides much reliable information that can be used in assuring adequate environmental controls for operations on leased Federal lands.

Many of the potential impacts will be common to most geothermal development in the Geysers KGRA but there still may be unique factors to be considered for a specific geothermal field or for individual leases. These will be appropriately including in individual lease stipulations.

To the maximum extent possible, consistent with meeting Federal responsibilities for the management and protection of public lands and their resources, appropriate consideration and utilization will be made of State of California and local government water quality, air quality, noise, geothermal and other laws and regulations. Section 270.41 of the regulations provides that the lessee shall comply with all Federal and state standards with respect to the control of all forms of air, land, water and noise pollution, including, but not limited to, the control of erosion and the disposal of liquid, solid and gaseous wastes. The Supervisor may, in his discretion, establish additional and more stringent standards which must be met. Volume I, Chapter III, Section C of the General Statement describes those potential environmental impacts that may be common to geothermal developments under various conditions. This information will not be repeated here. Instead this section generally will focus on specific mitigating measures directly relating to the Geysers area.

Mitigation of potential adverse impacts will be accomplished through application and enforcement of applicable Federal, State and local laws and regulations, and lease and land use permit stipulations under provisions of the geothermal regulations. Operational and environmental controls may be augmented or stated in greater specific detail through use of any or all of the following different methods: (a) Geothermal Resource Operational (GRO) Orders issued by the Supervisor, U.S. Geological Survey (Sec. 270.11); (b) the Plan of Operations (surface-oriented) as approved by the Supervisor and appropriate land management agency (Sec. 270.34); (c) applications for permits to drill new wells or perform remedial work (subsurface-oriented), approved by the Supervisor, (Sec. 270.71); (d) specific oral or written instructions from the Supervisor (U.S. Geological Survey) or surface land management agency (Bureau of Land Management, Forest Service, etc.), (Sec. 270.11). All of the aforementioned regulatory procedures are equally legally binding on the lessee. Local ordinances may be implemented as appropriate through one of the above regulatory procedures.

### 1. Monitoring

Monitoring, as appropriate, will be required of the following known impacts in the Geysers KGRA: noise, air quality, water quality, sediment transport, land subsidence, and seismicity. Noise and air quality impacts and water quality to a lesser degree may be identified with specific current operations, and the lessee would be required, by lease stipulations or other instructions, to provide such monitoring as deemed appropriate. Water quality and sediment transport as related to an entire drainage area normally would be the responsibility of the appropriate public agencies. Similarly, land-subsidence and seismic monitoring pertain to operations throughout the producing area and normally would be a responsibility of public agencies.

Currently, considerable monitoring activities are already under way. With respect to lands in Lake County, County Zoning Ordinance No. 645 requires compliance with specific noise standards and monitoring. In the area of water quality, Order No. 70-4 (Appendix G-4) requires monitoring to assure compliance with the provisions of the order. "Conditions, Procedures, and Performance Standards for Geothermal Regulation, County of Lake" is shown in Appendix G-5. Subsidence monitoring is scheduled by the National Oceanic and Atmospheric Administration, and the U.S. Geological Survey, in 1973. Specific aspects of monitoring are discussed in the following sections.

## 2. Unforeseeable Mishaps

Unforeseeable mishaps are not subject to rigid regulation, but the operating regulations provide authority for the Supervisor to act promptly to effect control over such immediate problems as blowouts and fires. Less immediate effects, such as land subsidence, increasing seismicity, and surface instability could be addressed under written GRO Orders.

The measures taken to mitigate the detrimental effects of three major blowouts in the Geysers field have already been discussed ("Test Drilling and Production Testing" in the general statement, and the two sections entitled Mishaps in this chapter.) The regulations contain specific provisions for controlling wells and for suppressing blowouts if they occur.

## 3. Land Resources

As used here, the term land resources applies to those surface-oriented activities and operations affecting the surface as distinguished from air and subsurface resources. Mitigating measures include those applying to multiple use of the surface, protection of aesthetic values, erosion control, and land-stability problems, including land subsidence, seismicity, and landslides.

Lease stipulations and GRO Orders will include all appropriate mitigating measures.

Such measures will be developed on a case by case basis covering factors such as:

- ...The need for revegetative requirements on disturbed areas.

- ...The degree to which seeding, mulching and revegetation practices should be completed prior to the beginning of the rainy season.

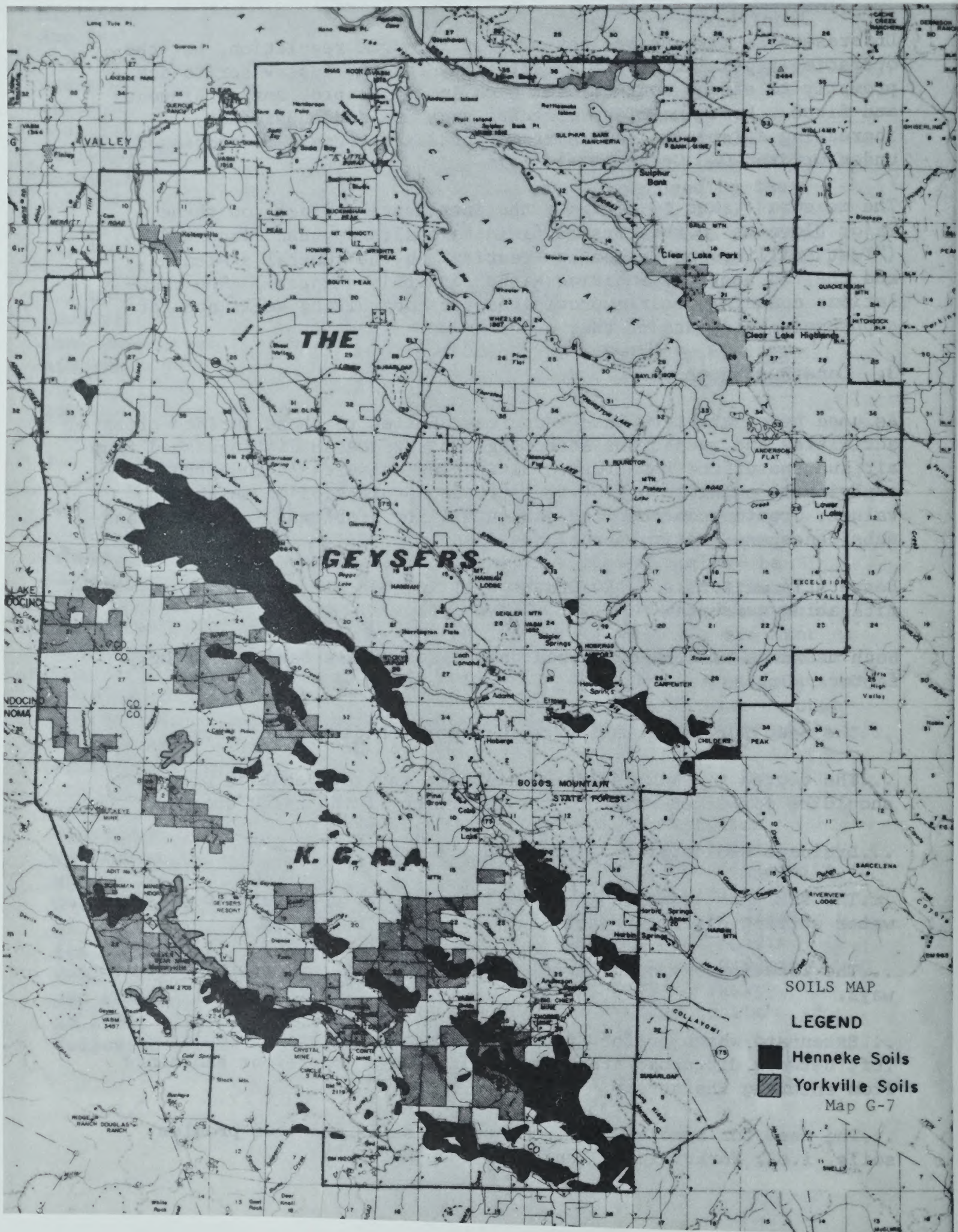
- ...Drainage and erosion control requirements.

- ...The size and location of culverts and water spreaders to prevent water cutting on fill areas.

- ...The location of roadbeds relative to streams and natural drainageways.

- ...Extent to which buffer strips of natural vegetation should be left between disturbed areas and drainageways to prevent sediments from entering the stream.

- ...The need for special requirements for slide prone or problem soils, i.e., Yorkville or Henneke. (See Map G-7)



Mitigation of land instability problems is less clear-cut than the more obvious matters dealt with above, because to date such effects have not proven to be operating problems in the Geysers KGRA. Many natural slide areas have been mapped in the Geysers field and these known areas of slope instability should be considered in planning well locations, steam transmission lines, power plants, electrical transmission lines, and electrical transmission facilities. Construction activity has created new areas of shallow slope instability of minor extent; however, these are monitored and repaired as necessary to provide both plant protection and public safety. The most effective preventive measure is to provide soil drainage in susceptible materials to prevent saturation of soil and underlying rocks. To the extent that grading provides such drainage, it tends to minimize the landslide problem. Large fills tend to aggravate the problem and will require special techniques, including selected areas for fill, notching of fills into original ground, and special drainage designs.

#### 4. Water Resources

The Federal Government and the State of California share the responsibility for the administration of water pollution control, under terms of the Federal Water Pollution Control Act. In California this responsibility is vested in the State Water Resources Control Board. Enforcement of State-Federal regulations is carried out by nine regional water quality control boards. The present productive area of the Geysers field in Sonoma County is in the area of jurisdiction of the North Coast Regional Water Quality Control Board; the parts of the Geysers KGRA in Lake County are under the jurisdiction of the Central Valley Regional Board.

Water pollution control is exercised by the regional boards by the procedure of waste discharge orders issued for specific waste discharge situations. Order No. 70-4 (Appendix G-4) of October 29, 1970, illustrates how this procedure is applied to the present active unit production operation, which supplies steam to, and disposes of discharge from, the Pacific Gas and Electric Company plants at the Geysers.

In addition to State and Federal regulations pertaining to water pollution, it is expected that the presently accepted practice of returning all waste fluid to the producing reservoir will be required of Federal lessees. It should be noted the Waste Discharge Order 70-4 also addresses the problems of disposal of drilling fluids, toxic materials, and sediment yield to streams of the area. These provisions could likewise be made applicable to Federal leases. Stream quality has been monitored at two sites on Big Sulphur Creek since 1968, by the Union Oil Company and the data has been given to the California Water Resources Control Board.

At each station samples are collected monthly for measurement of temperature, specific conductance, turbidity, color, pH, suspended solids, nitrogen nutrients, common ions (Ca, Mg, Na, HCO<sub>3</sub>, Cl, SO<sub>4</sub>), and dissolved oxygen. Thus, some prior data is available for comparison after operations begin on Federal lands as a measure of the impact on the stream environment.

Appropriate regulations and monitoring measures will be included in lease stipulations or GRO to avoid water pollution. However, there still could be mishaps or accidents that will pollute drainage waters. Requiring proper revegetation of disturbed ground areas and prohibiting access roads, well and power plant sites near live streams are actions that will mitigate stream pollution.

## 5. Air Resources

Existing power plants at the Geysers emit H<sub>2</sub>S in amounts over the 0.03 ppm established by the California Air Resources Board as the unpleasant odor threshold. In a recent report to the Public Utilities Commission of the State of California, PG&E indicated that test results for abatement of cooling tower H<sub>2</sub>S emissions had achieved an abatement rate of 70 percent with over 90 percent abatement achieved over short time periods. (PG&E Report 7485.7-73)

Power unit 12 which was begun in July 1973 is designed to meet the ambient air quality requirements for H<sub>2</sub>S. Other noxious gases that are combined with geothermal steam will also be reduced at the generating unit. The Federal Government can utilize these advances by requiring that any power units constructed on national resource lands be designated to meet California's ambient air quality standards for H<sub>2</sub>S.

## 6. Fish and Wildlife

Examples of mitigating measures that may need to be considered to help offset fish and wildlife losses include:

... Prompt revegetation of exposed land after soil disturbance. Plants could include legumes as well as annual and perennial grasses thereby possibly improving wildlife habitat for some species. Mulching and fertilizing may be needed in some areas.

... Wildlife watering devices where roads, well sites, or other developments alter natural springs.

... The need to restock streams with trout in the event that geothermal development activities cause a significant fish population reduction.

... Appropriate measures to minimize the electrocution of eagles, hawks, and other birds by power transmission lines.

In order to minimize mortality of eagles, hawks, and other birds, power distribution lines are to be designed and constructed in accordance with REA Bulletin 61-10 (Powerline Contacts by Eagles and Other Large Birds).

Other measures also may be possible for prevention of electrocution bird losses. A feature article in the Wall Street Journal (July 11, 1973) describes recent research relative to the prevention of eagle electrocution. It was found that a mature eagle swoops under the outside wire of powerlines, then zooms upward with wings folded tightly to the body until it sets atop the crossarm, never touching two wires at once. By contrast, young eagles seem to fly awkwardly downward to the crossarm with their wings extended which may short out the two wires touched and electrocute the birds. The study indicates that by raising the center wire approximately 38 inches such contact cannot be made. The cost of alteration is estimated to be about \$100 to \$135 per pole. Other alternatives could include wrapping protective insulation around the center contact wire or constructing a special safe perch atop the pole.

## 7. Archaeological and Historic Values

Section 3204.1(h) provides that the lessees shall conduct activities on discovered, known or suspected archaeological, paleontological, or historical sites in accordance with lease forms or specific instructions applicable to each lease. Both the lessee and the Supervisor will have to constantly be alert to such values and take appropriate measures to protect archaeological and historic values.

## 8. Seismic and Subsidence Measures

There has been no evidence of either seismic or subsidence adverse impacts from geothermal production on private lands within The Geysers KGRA. However, little is known about the tectonic stress field in this area. In regions of high tectonic shear stress, there may be high risk of triggering earthquakes by fluid injection. Appropriate monitoring of areas subject to seismic or subsidence impacts will be accomplished. In the event such monitoring detects the need for corrective measures, appropriate actions such as reduction of injection pressures, halting of injection, or possibly the accelerated withdrawal of fluids will be taken.

E. ADVERSE IMPACTS WHICH CANNOT BE AVOIDED SHOULD THE PROPOSAL BE IMPLEMENTED

The geothermal rules and regulations, lease provisions, and GRO Orders are designed to assure that geothermal resources can be developed and utilized in an environmentally acceptable manner. However, virtually any human use of lands and their resources may have some degree of adverse impact. (See Volume I, Chapter III, Section D for further discussion of the subject)

Implementation of the proposed geothermal leasing in The Geysers KGRA would result in the following adverse impacts:

1. Exploration Phase

Increased vehicle travel will occur with the attendant dust exhaust gases, noise, disturbance of wildlife, injury or killing of livestock or wildlife and accidents. When existing roads can be used, some of these impacts will be lessened.

Although advance approval will be required for construction of new roads or trails, disturbance of vegetative cover and soil can be expected until cover is restored and the soil stabilized. Roads and trails, even after geothermal exploration is completed, invite increased use by off-road vehicles and hunters. Such use increases the risk of fires. Surface disturbance scars are more severe in the steep topography of The Geysers KGRA and are visible for many years.

2. Test Drilling Phase

After a lease is awarded, heavy equipment capable of drilling to depths of several thousand feet would be required.

Enlargement and improvement of existing roads or construction of new roads would be necessary to provide access for the drilling equipment. At each drilling site, a level area is needed on which to erect the drilling equipment. In the steep topography found in this KGRA, a drill site normally requires one to three acres. The surface disturbance in this phase of the operation is similar to, but more extensive than in the exploration phase. The result is a more pronounced effect on aesthetics and increased erosion potential. During road construction and drilling activities, noise levels as shown in Table G-8 can be expected. Venting of test wells add significantly (65db) to the noise level up to 1500 feet from the operation.

Because of increased danger to the public, access to the Federal lands might be restricted. This action could reduce the recreation opportunities on or adjacent to any area being developed.

Well blowouts, although they are not expected to be a problem in The Geysers KGRA, are still a possibility due to human error, equipment failure or other factors. The seriousness of an incident could range from minor to major. A significant factor would be the action of the geothermal steam or liquid. If the wells include dry steam such as is produced from the presently developed area, impacts would be less since virtually all of the flow would be to the atmosphere, than might result from a highly mineralized or brine geothermal fluid which could enter stream systems. The effects could include danger to humans, surface disturbance, venting of steam into the atmosphere, air contamination, water contamination, increased sediment levels, and increased noise.

### 3. Production Testing Phase

During production testing, a large volume of steam is released into the air. Testing normally lasts from several weeks to some months until the flow stabilizes at a uniform level. During this period, noise impact and gaseous emissions are at their maximum level. Table G-9 shows that composition of the noncondensable gases from steam wells at The Geysers. Since the average  $H_2S$  level is .0461% and the California Air Resources Board established .03 ppm as the unpleasant odor threshold, venting steam wells can be expected to emit a rotten egg odor to the surrounding atmosphere.

Noise levels of muffled venting steam wells add 65 db at 1500 feet.

### 4. Full Scale Operations Phase

Soil disturbance and vegetative loss will probably cause the most significant impacts in The Geysers KGRA. A minimum of 6-8% of the native vegetation could be lost when an area is under full geothermal development. Such a loss pertains to a development unit of 15-25 wells, one power plant, steam pipes, and roads on 600-1,000 acres. Examples of potential adverse impacts caused by loss of vegetation are:

- Some hydraulic function loss of the drainages which would result in increased runoff rates.
- Wildlife population reductions caused by direct habitat loss.?
- Siltation of streams with consequential damage to fish and other aquatic life.

However, the loss of native vegetation would be mitigated to a degree by the planting of grass and other appropriate vegetation under steam pipes, along road banks, around buildings and on firebreaks. During construction there would be increased activity, noise, movement of earth and dust. After construction is completed the site would have changed from natural wildlands to an industrial complex. Even with all necessary environmental protection measures, the cuts, fills, buildings, and pipelines, could represent permanent changes in the landscape.

Full scale operation would involve noise levels as shown on Table G-8, emission of steam and other gases to the atmosphere and additional vehicle traffic. Even with environmental controls, lease stipulations, and regulations, these impacts cannot be avoided.

Land uses associated with wildlands could change. Recreation, hunting, fishing, hiking, and riding may not be possible in some areas and might be modified in others. The use of the area by livestock and wildlife could be modified.

Mishaps can occur (i.e. blowouts) that could temporarily affect the environment in the immediate vicinity. Wildfire frequency may increase because of increased human activities in the area. These effects are discussed in detail in Volume I Chapter III of the General Statement.

The geologic characteristics that normally cause subsidence do not appear to be present at the Geysers. Pronounced changes in fluid pressure in confined systems as a result of the removal of geothermal fluids could cause instability in the subsurface and subsequent micro-earthquakes.

F. THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Leasing of lands for geothermal resource development would involve commitment of geothermal resources together with the water and land resources of the areas involved. The extent of these commitments and an assessment of their environmental impacts have been described in the preceding sections. However, the relationships between these proposed uses of the environment and the maintenance and enhancement of its long-term productivity are discussed below: (Also see Volume I, Chapter III, Section E for additional discussion of this subject)

1. The Resource

A potentially valuable natural resource underlies some or all of the government lands lying within the present apparent boundaries of the Geysers KGRA. This resource is a large volume of dry steam buried deep within the earth. The major steam resource occurs in hard, fractured graywacke at depths of about 2,000 to 9,000 feet, or deeper. The temperature in the reservoir is mostly within the range of 460-480 degrees F. and the pressure 475-500 psi. This is an unusual resource in that such dry steam reservoirs have been found in only a few places in the world.

Pressure interference and pressure decline tests have been made in many of the producing wells in the field. The results of these tests have shown that the deep steam reservoir is essentially a closed system. (See references: C. F. Budd; also Tax Court of the United States, 52 T. C. No. 74.) The reservoir is not being recharged with water at a rate great enough to prevent pressure decline as the field is produced. If the government lands are not leased, the steam underlying these lands will be withdrawn in part or in total by wells on adjacent private lands.

2. Water

Consumption of water resources by power plants would constitute a depletion of gross water resources available to the area. However, the geothermal fluids that would furnish the input water to such plants is mineralized steam, not presently used for other purposes. To the degree that such fluid withdrawn from the subsurface reservoir is not replenished by reinjection or natural recharge, the water consumed would represent a depletion of water in storage.

Degradation of runoff water is expected to be most severe during, and immediately following construction. Appropriate surface treatment and revegetation measures will provide initial surface protection. Most disturbed sites will tend to naturally re-vegetate within 10 years and thus reduce soil loss and stream sediment load.

### 3. Land

Land uses on federal leases would be changed from natural open space, hunting, and other recreational uses to power production near the power plant complexes. Public use in the vicinity of such industrial facilities may be restricted as a safety measure and to reduce vandalism.

Land resources and vegetation would be affected by the construction of roads, wells, plant and transmission facilities. After de-commissioning of the above ground appurtenances, the majority of the sites could be returned to their former productivity. An exception to this would be the rocky cuts where the lack of soil would prevent reestablishment of the original vegetative cover. These areas would probably cover less than five percent of the area that was developed.

### 4. Fish and Wildlife

Some of the detrimental effects to fish and wildlife, especially habitat loss, could continue as long as electrical production continues. The completion of drilling activities will lessen the disturbance factor. Steam pollution from sedimentation and sump pond chemicals would be less severe as time progresses.

The leasing of Federal lands could also have a long-term effect for some species such as the golden eagle. Such species also rely on other areas in the western States which are succumbing to developmental pressures. The overall effect is a decrease in the populations. However, the Federal lands in the Geysers KGRA comprise 15 percent of the potential geothermal development area, and the federal lands are intermingled in small parcels with the private land. This private land resources probably will continue to be developed so most of the potential impacts will occur whether or not the Federal lands are leased and developed.

### 5. Economic and Social

The energy source tapped by geothermal development is not otherwise used. Most areas in the KGRA potentially subject to Federal geothermal lease have present surface uses which have less economic value than geothermal power. Geothermal development therefore would increase the productivity of the region and the nation by either making use of previously unemployed resources, or employing resources in a more valuable way.

A steam field is expected to be subject to exhaustion. After steam production ceases it may be returned to its prior use. The government lands could be returned to production of wildlife, agricultural products, water, and other minerals. There is no reason to expect that steam production is entirely incompatible with these other uses.

It is entirely possible that some current uses of this land will be only slightly diminished by geothermal leasing. Other uses may be enhanced. Thus, it appears that geothermal leasing would contribute to both the short-term and long-term productivity of some of the government lands.

G. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION SHOULD IT BE IMPLEMENTED

The principal commitment of resources would be the depletion of thermal energy from the geothermal reservoir. The reservoir is believed to be a closed system and the steam could be depleted under full development. Once the steam reservoir is depleted to the point where economic production could not continue, production would stop, facilities would be removed, and the area would be restored to as nearly a natural state as possible. There is no foreseeable alternative use of the stored energy other than possible space heating.

Development of the land surface to power plants, well sites, pipe lines, transmission lines, and roads will result in alteration of vegetative cover and aesthetic values. While not of a permanent nature, such uses will represent a commitment for a period of 25-50 years after completion of the project.

The capital and labor required for the geothermal development represent an irretrievable commitment of those resources, because installations would have little salvage value when the geothermal resources are exhausted.

## H. ALTERNATIVES TO PROPOSED ACTION

The proposed action is leasing of federally owned potential geothermal resources in The Geysers KGRA.

Alternatives for the proposed geothermal leasing (also see Volume I, Chapter IV of the General Statement) follow:

- (1) The Secretary could postpone geothermal leasing pending further study of the environmental impact. This would mean that, on a short-term basis, there would be no direct environmental impact on government lands from Federal leases. Non-Federal geothermal development would continue in the area and additional information on the environmental effects of development would be accumulated from that source. Federal leasing might be permitted at some future date with less adverse impacts due to utilization of the increase in knowledge.
- (2) The Secretary could decline to issue any leases to develop federally owned geothermal resources. This would mean that there would be no direct environmental impact from geothermal development on government lands. Development of non-Federal geothermal resources would be expected to continue at an expanding rate.
- (3) Lease only those lands on which the mineral rights have been reserved to the government. There are approximately 14,000 acres of this type land in the KGRA. Some of this land is currently being used for homes, cabins, mines, and agricultural and recreational purposes. Owners of surface rights may demand compensation for losses should geothermal development occur. (See map in pocket at the end of this volume.)
- (4) Lease the national resource lands. There are approximately 11,150 acres of this type land in the KGRA. Less surface development has been made on these lands than on the mineral reserved lands. (See map in pocket at the end of this volume.)
- (5) Lease to honor the grandfather rights for conversion to geothermal leases. Grandfather applications exist for both the national resource lands and lands for which the government owns only the mineral rights. Applications for conversion total 13,286 acres. This over-states the actual land area involved because there are many overlaps in the applications. The actual total will be about 11,000 acres, dependent upon adjudication of the conflicts.
- (6) Lease to honor grandfather rights on the national resource lands.
- (7) Lease to honor grandfather rights on lands where mineral rights only are reserved to the government.

The following leasing alternatives may be applied to national resource lands, mineral reserved lands, and/or grandfather lands:

- (8) Lease in connection with the related private land geothermal resource development to complete logical resource and/or economic units. The government would be taking a relatively passive stand concerning the pattern of development in this case.
- (9) Lease only selected areas where geothermal development is compatible with existing land uses in the area.
- (10) Lease only the areas with the greatest probability of developing producing wells.
- (11) Lease a prototype area to gain experience in the management of geothermal resources.

Under alternatives 1 and 2, energy needs, which could otherwise be supplied by geothermal development on government lands, would probably be met by utilizing other energy sources, e.g. fossil fuel or nuclear plants. Leasing of less than the entire government geothermal resource (alternatives 3-11) would imply less energy source substitution. A discussion of various energy alternatives is presented in Volume I, Chapter IV of the program portion of this impact statement.

The government lands are a small part of The Geysers field. Development of the geothermal resource on private lands is continuing and will continue until the reservoir is completely developed. Most of the environment will be exposed to the impact of development whether or not the government lands are leased and included in the development.

Experience with the production of oil and gas has shown that the most efficient way to develop a field is to treat the entire reservoir as a single unit. Under unitization, wells will be spaced so as to drain the reservoir most efficiently and to supply steam to the generating plants with the least loss of energy, without regard to property lines. Leasing of the government geothermal resource would permit it to be included in the unit and contribute to the orderly and efficient development of the field.

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Soils

Butte

Henneke

Josephine

Konokti

Laughlin

Los Gatos

Maymen

Yorkville

## BUTTE SERIES

The Butte series is a member of a fine loamy, mixed, thermic family of Ultic Haploxeralfs. (See Remarks). The soils have light brownish gray, medium acid, gravelly loam A horizons and white, heavy loam, strongly acid B2t horizons. Tuffaceous bedrock is at 32 inches.

Typifying Pedon: Butte gravelly loam - forested  
(Colors for dry conditions unless otherwise stated)

A1 -- 0-4" -- Light brownish gray gravelly loam (10YR 6/2) very dark grayish brown (10YR 3/2) moist; moderate fine and medium granular structure; weakly coherent, very friable, nonsticky and nonplastic; abundant very fine roots, many very fine interstitial pores; medium acid (pH 6.0); abrupt wavy boundary. 4-18 inches thick.

B1t -- 4-13" -- Pale brown (10YR 6/3) gravelly heavy loam, dark grayish brown (10YR 4/2) moist; weak medium granular structure; weakly coherent, very friable; nonsticky, slightly plastic; plentiful fine, few medium roots; many very fine tubular and interstitial pores; few thin clay films in pores and as bridges between mineral grains; medium acid (pH 5.7); clear wavy boundary 8 - 10 inches thick.

B2t -- 13-22" -- White (10YR 8/2) heavy loam, brown (10YR 4/3) moist with common fine distinct grayish brown mottles; weak medium granular structure; slightly hard, very friable, nonsticky, slightly plastic; plentiful fine roots; many very fine tubular and interstitial pores; few thin clay films in pores and as bridges between mineral grains; strongly acid (pH 5.3); clear wavy boundary. 7 - 11 inches thick.

C -- 22-32" -- White (10YR 8/1) heavy loam, light brownish gray (10YR 6/2) moist, with common fine distinct dark brown mottles; massive; weakly coherent, very friable, nonsticky, slightly plastic; very few fine, few very fine roots; many very fine tubular pores; few thin clay films as bridges; medium acid (pH 5.7); clear wavy boundary. 10 - 20 inches thick.

R -- 32-37"+ -- Rhyolitic bedrock, massive and slightly weathered.

Type Location: Napa County, California on Pacific Union College property along Inspiration Point Road, 1,000 feet north and 200 feet east of center of Section 4, T.8N, R.5W.

Range in Characteristics: Solum thickness is 19 to 39 inches to the bottom of the Bt and mean annual soil temperature ranges from 60 to 62°F. Depth to rhyolitic bedrock is 32 to 59 inches. Mineralogy probably is mixed. The soils are dry in some subhorizon for 90 or more cumulative days most years, but not continuously dry in all parts for as long as 60 days. The A horizons are ochric with colors in the 10YR hue and with values of 5 or 6 dry and 3 moist. Chromas are 2 to 3. Texture ranges from gravelly sandy loam to gravelly heavy loam; structure from weak to moderate granular; consistence from weakly coherent to slightly hard, friable to very friable, and nonsticky and nonplastic to slightly plastic. Reaction is medium acid. The Bt horizon colors are in the 10YR hue with values of 6 to 8 dry and 4 moist. Chromas are 1 to 3. Texture ranges from heavy loam to clay loam, nongravelly to gravelly; structure from weak granular to subangular blocky; consistence is similar to that of the A horizon and reaction is strongly acid.

Competing Series and Their Differentiae: These include the Cone, Forward, Honn, Inks, Jiggs, Kidd, Laniger and Spreckels series. The Cone, Forward, Jiggs, Kidd and laniger soils lack Bt horizons. The Honn soils lack an R layer and have umbric epipedons. The Inks soils are lithic, and the Spreckels soils have clay Bt horizons and abrupt AB boundaries.

Setting: The Butte soils occur on gently sloping to steep uplands at elevations of 500 to 2,000 feet. The regolith is rhyolite or tuff that is jointed and weathered along the cracks. The climate is Mediterranean with mean annual rainfall of 35 to 55 inches, and with hot dry summers and cool, moist winters. Mean annual temperature is about 58°F, average January temperature about 50°F, and average July temperature about 68°F.

Principal Associated Soils: The Butte soils occur in the same general areas as the upland Hugo soils on shales and sandstones and the Red Hill soils on basic volcanic rocks; and the deep Coombs and Spreckels soils on terraces.

Drainage and Permeability: Well drained, medium runoff and moderately slow permeability.

Use and Vegetation: Used for forestry and grazing. A few areas are planted to grapes. Native vegetation includes conifers, madrone, oaks, shrubs and grass.

Distribution and Extent: North Coast Ranges of California. The soils are inextensive.

Series Established: Napa Area, California, 1933.

Remarks: The Butte series was formerly classified in the Yellowish Brown Lateritic group. The current classification is based on an ochric epipedon that is darker than a value of 3.5 when moist and an argillic horizon with a base saturation of less than 75%. The soils may contain 60% or more of ash, and would be classified as Andic Ultic Haploxeralfs, ashy, thermic family.

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### HENNEKE SERIES

The Henneke series is a member of the clayey-skeletal, serpentinitic, thermic family of Lithic Argixerolls. Typically, Henneke soils have brown, slightly acid gravelly loam A horizons and brown, neutral, very gravelly clay loam B2t horizons over serpentine bedrock.

Typifying Pedon: Henneke gravelly loam - shrubs  
(Colors are for dry soil unless otherwise stated)

- 01&02 1/2-0"--Fresh and partly decomposed leather oak leaf litter mixed with much medium sized gravel; abrupt smooth boundary.
- A1 0-3"--Brown (7.5YR 4/3) gravelly loam, very dark brown (7.5YR 2/2) moist; strong very fine granular structure; soft, very friable, few very fine and fine roots; many very fine and fine pores; about 35 percent rock fragments; slightly acid; abrupt smooth boundary. (1 to 4 inches thick)
- B1 3-10"--Brown (7.5YR 4/4) very gravelly clay loam, dark brown (7.5YR 3/2) moist; weak medium subangular blocky structure that parts to strong fine and very fine granules; slightly hard, friable, slightly sticky, slightly plastic; few very fine and medium roots; many very fine and fine pores; thin nearly continuous clay films lining a few pores; about 40 percent rock fragments; neutral; clear irregular boundary. (4 to 7 inches thick)
- B2t 10-19"--Brown (7.5YR 4/4) very gravelly clay loam, dark brown (7.5YR 3/3) moist; moderate medium subangular block structure; slightly hard, firm, slightly sticky, slightly plastic; some pores, but clay mainly in bridges between mineral grains; about 40 percent rock fragments; few angular cobblestones; neutral; abrupt irregular boundary. (7 to 9 inches thick)
- R 19-24"--Fractured greenish blue serpentine rock; a few cracks filled with soil material from above; thick clay films on rock faces in fractures.

Type Location: Tehama County, California; about 5 miles west and 1 mile north of Paskenta; near the SW corner sec. 7, T.24N., R.7W.

Range in Characteristics: Depth to a lithic contact of hard somewhat fractured serpentine rock is 12 to 20 inches. Rock fragments including sand size are fragments of serpentine rocks. Soil from the depth of about 5 inches down to bedrock is usually moist all of the time from late October or November until sometime in May and is dry all the rest of the year. Mean annual soil temperature just above the bedrock is about 60° to 62°F. The soils have a Ca/Mg ratio of 1:1 or less and have problems of soil fertility. The A horizon is brown or dark brown in 7.5YR hue, reddish gray, dark reddish gray or reddish brown in 5YR hue or weak red or dusky red in 2.5YR hue. Moist chroma and moist value are 2 or 3. The A horizon is loam or clay loam modified by 20 to 40 percent rock fragments, mostly

of gravel size. It has dominantly moderate or strong granular structure though some pedons are subangular blocky and some have platy structure at the immediate surface. This horizon is neutral, slightly acid or medium acid. It contains 2 to 7 percent organic matter. The B2t horizon is dark brown or brown, dark reddish brown, reddish brown or reddish yellow (6/6) in 5YR hue, dusky red, reddish brown or red (4/6, 5/6 in 2.5YR hue). It is heavy clay loam or clay with 35 to 50 percent clay and 35 to 50 percent rock fragments. This horizon has blocky or subangular blocky structure. It has 1 to 2 percent organic matter and is neutral steep to moderately alkaline. Few roots and very little soil are in joints of the rock and none below a few inches.

Competing Series and their Differentiae: These are the Delpiedra, Dubakella, Huse, Montara, and Stonyford series. Delpiedra, Stonyford, and Dubakella soils lack mollic epipedons, and Dubakella soils lack a lithic contact above depth of 20 inches. Huse soils lack argillic horizons and mollic epipedons. Montara soils lack argillic horizons.

Setting: Henneke soils are on rolling to steep slopes at elevations of 1,000 to 4,000 feet. The soils formed in residuum weathered from serpentine and rocks of similar mineralogy. Rock outcrops, stones, and cobblestones are common and occupy 5 to 50 percent of the surface. The climate is subhumid mesothermal with warm dry summers and cool moist winters. Mean annual precipitation is 16 to 45 inches. The mean annual temperature is about 58° to 60°F; the average January temperature is about 40°F., and the average July temperature is about 70°F. The freeze-free season is steep about 200 to 250 days.

Principal Associated Soils: These are the competing Dubakella, Huse, Montara, and Stonyford soils, and the Hugo soils. Hugo soils are more than 40 inches deep and lack an argillic horizon.

Drainage and Permeability: Well to excessively drained; medium to very rapid runoff; moderately slow permeability.

Use and Vegetation: Used mostly for wildlife and watershed. The principal native plants are scattered oaks, Digger pine, Coulter pine, cypress, and shrubs such as leatheroak, whiteleaf manzanita, muskbrush, and toyon. Grasses are sparse, usually squirreltail and a few annuals.

Distribution and Extent: Coast Ranges and foothills of the Sierra Nevada and Klamath Mountains of California. The soils are extensive.

Series Established: Mendocino County, California, 1951.

Remarks: The Henneke soils were formerly classified as Brunizems.

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JOSEPHINE SERIES

The Josephine series consists of well drained (medial) Reddish Brown Lateritic soils developed from sandstones and shales that may be metamorphosed in and from schists. They occur on moderate to very steep slopes under mixed coniferous forests. Characteristically, the Josephine soils have brown to reddish brown, about medium acid, medium textured A horizons which grade into strong brown to yellowish red, medium to strongly acid, moderately fine textured B2 horizons at moderate depths. JOSEPHINE soils occur in the same general area as Cohasset, Fiddletown, Hugo, Mariposa, and Sites soils. They resemble Butano, Cohasset, Hugo, Los Gatos, Mariposa, and Sites soils. Butano soils, developed in siliceous shales, have light brownish gray A1 horizons that grade into brown B2 horizons. The Cohasset soils, developed in basic igneous rocks, typically have chromas of 3 or 4 throughout their profiles. Hugo soils lack Bt horizons and have brownish (10YR or 7.5YR) hues. Los Gatos soils, developed under shrubs, have low C/N ratios in their A horizons and are about slightly acid. Mariposa soils are shallow or very shallow and have thin (usually 4 to 9 inches), loam or light clay loam B2 horizons. Sites soils are deep or very deep and have fine textured, medium or strongly acid, yellowish red or red B2 horizons. JOSEPHINE soils occur at elevations of about 1,000 to 3,000 feet in a moist subhumid, mesothermal climate having mean annual precipitation of about 30 to 55 inches, with warm dry summers and cold wet winters; an average January temperature of about 45°F.; an average July temperature of about 70°F.; a mean annual temperature of about 55°F.; and an average frost free season of about 140 to over 200 days. The Josephine soils are of fairly wide distribution and are extensive.

Soil Profile: Josephine loam

0	1-0"	Fresh and partly decomposed fir needles and other forest litter; abrupt smooth boundary. 1 to 3 inches thick.
A1	0-3"	Reddish brown (5YR 5/4) loam, dark reddish brown (5YR 3/4) moist; moderate very fine and fine subangular blocky structure breaking to weak medium granules; slightly hard, friable, slightly sticky, slightly plastic; many very fine and fine roots; many very fine pores; few fine gravel; medium acid (pH 5.8); clear smooth boundary. 3 to 5 inches thick.
A3	3-7"	Light reddish brown (5YR 6/4) loam, reddish brown (5YR 4/4) moist; moderate fine angular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; many very fine and fine, few medium and coarse roots; many very fine, few fine pores; few gravel; medium acid (pH 5.8); clear smooth boundary. 0 to 16 inches thick.

- B1 7-14" Light reddish brown (5YR 6/4) light clay loam, moderate medium blocky structure; slightly hard, friable, slightly sticky, slightly plastic; common thin discontinuous clay films on ped faces; many fine and few coarse roots; many very fine, few fine pores; clear smooth boundary. 0 to 20 inches thick.
- B21t 14-25" Light reddish brown (5YR 6/4) sandy clay loam, reddish brown (5YR 4/4) moist; moderate coarse subangular blocky structure; hard, friable, sticky, plastic; thin continuous clay films on ped faces and in many pores; many very fine and fine, few medium and coarse roots; many very fine, few fine pores; medium acid (pH 5.6); clear smooth boundary. 9 to 20 inches thick.
- B22t 25-40" Yellowish red (5YR 5/6) clay loam, yellowish red (5YR 4/6) moist; moderate medium and fine angular blocky structure; thin continuous clay films on ped faces and in some pores; hard, friable, sticky, plastic; few very fine to medium roots; many very fine pores; medium acid (pH 5.6); clear, smooth boundary. 0 to 18 inches thick.
- B3 40-55" Light yellowish brown (10YR 6/4) fine sandy clay loam, yellowish brown (10YR 5/4) moist; massive; very hard, firm, slightly sticky, slightly plastic; few roots and pores; thin continuous reddish brown (5YR 4/4) clay films on rock fragments; shattered rock fragments comprise about 70% of this horizon, which grades into bedrock.

Range in Characteristics: The A1 horizon ranges in color from pale brown through yellowish red (10YR 6/3 to 5YR 4/4 dry), 1 or 2 values lower when moist; in texture from silt loam to loam or gravelly loam, inclusive; and in reaction from slightly through medium acid. The A1 horizon grades into the B2 horizon through either or both of A3 and B1 horizons with transitional properties. The B2 horizon ranges in color from brown or strong brown through reddish yellow, light reddish brown, or red (7.5YR to 2.5YR hues); in texture from clay loam to silty clay loam, inclusive; and in reaction from medium through strongly acid, generally and rarely, very strongly acid. The depth to rock ranges from about 20 inches to over 60 inches, 36 to 48 inches being average. The hardness of the parent rock ranges from firm to slatelike where strongly metamorphosed. Areas of metamorphosed rocks, particularly where folded, are extremely variable both in depth and color within short distances. Colors given are for dry conditions unless otherwise stated.

Topography: Moderately steep to very steep slopes in mountainous areas.

Drainage and Permeability: Well drained; moderate runoff; moderate permeability.

Vegetation: Douglas fir, Ponderosa pine, sugar pine, incense cedar, black oak, Oregon white oak, madrone, big leaf maple, manzanita, poison oak, mountain misery, perennial grasses.

Use: Mainly for timber. Less steep, particularly on lower footslopes, areas may be cleared for pasture or orchard crops.

Distribution: Coast Range section of southern Oregon and mountainous areas of northern and central California.

Type Location: Josephine County, Oregon; 1.8 mi. east of O'Brien, 30 ft. north of O'Brien-Takilma Rd, NE $\frac{1}{4}$  NW $\frac{1}{4}$  NE $\frac{1}{4}$  Sec 29, T.40S, R.8W.

Series Established: Josephine County, Oregon, 1919. (Name from that of county.)

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## KONOKTI SERIES

The Konokti soils are Red Podzolic soils developed in place on dacites and andesitic rocks and tuffs, under rainfall of 30 to 50 inches, wet winters with frequent frosts and occasional snow, and long dry summers. The soil materials contain no lime and are acid in reaction. The soils are associated with and somewhat similar to the Butte series, from which they differ in their reddish-brown color. Gravelly and stony loam and clay loam types predominate:

### I. Soil Profile: (Konokti gravelly clay loam)

1. Pale or dull reddish-brown clay loam containing many angular fragments of parent rock and numerous small rounded iron-and manganese-cemented pellets or concretions; granular to soft lumpy structure, breaking up easily under cultivation; porous and permeable to roots and water, and permeated with worm and insect channels and burrows; high water-holding capacity. In undisturbed virgin areas there is a thin surface horizon of darker-brown color consisting of decomposed forest litter mixed with mineral soil material; about 6 inches thick, underlain by;
2. Light reddish-brown acid gravelly clay loam, somewhat heavier than the layer above; in places distinctly red or dull red, grading to yellowish-brown; moderately compact; breaks into clods; contains numerous rock fragments and a somewhat smaller amount of shot pellets; underlain at 18 to 24 inches by;
3. Pale reddish-brown to dull-red compact gravelly clay loam or clay; underlain at depth of 40 to 50 inches by
4. Bedrock, partially weathered or somewhat fractured in the upper part.

II. Variations: Prominent variations consist of differences in depth to bedrock, which usually occurs at 3 to 6 feet. Shallow, steep, and stony phases are included.

III. Topography: Hilly to mountainous, with gentle to steep slopes, usually of smooth surface but broken in places by rock outcrop.

IV. Drainage: Run-off takes place rapidly and subdrainage is generally favorable though somewhat retarded in places by shallow bedrock. The soils absorb water quickly and erosion is usually not severe.

2 - Konokti Series

- V. Natural Vegetation: Mainly pines with occasional oaks and in places dense growth of ceanothus, manzanita, and associated shrubs, mainly in the shallow or burned-over areas.
- VI. Use: Only a small proportion of the Konokti soils has been cleared of timber or brush. They are used mainly for pasture. Small areas are used for walnuts, prunes, and pears, usually without irrigation. Under favorable rainfall the deeper soils are productive.
- VII. Distribution: Coastal mountain areas in north central California.

Type location: Mount Konokti, Lake County, California

Series established: Clear Lake Area, Lake County, California, 1927.

MHL-FOY-MB  
4-11-40

Division of Soil Survey  
Bureau of Plant Industry  
U.S. Department of Agriculture

## LAUGHLIN SERIES

The Laughlin series is a member of a fine-loamy, mixed, mesic family of typic Haploxerolls. These soils have brown, medium acid, loam A horizons; and brown, strongly acid, light clay loam C horizons. The soils are moderately deep to hard sedimentary bedrock.

Typifying Pedon: Laughlin loam - range

(Colors are for dry conditions unless otherwise noted).

A1 -- 0-4" -- Brown (10YR 5/3) loam, very dark grayish brown (10YR 3/2) moist; massive; slightly hard, friable, non-sticky, and slightly plastic; many very fine and fine roots; many very fine and few fine interstitial and tubular pores; medium acid; clear smooth boundary; 2 to 12 inches thick.

C -- 4-22" -- Brown (10YR 5/3) sandy clay loam; very dark grayish brown (10YR 3/2) moist; massive; hard, friable, non-sticky, slightly plastic; many very fine and fine roots; common very fine and fine interstitial and tubular pores; strongly acid; clear irregular boundary; 8 to 20 inches thick.

R -- 22"+ -- Yellowish brown, fractured and weathered, medium grained sandstone (graywacke); few thin patchy clay films along fractures.

Type Location: In Sonoma County, California. 6.4 miles NNE of Ft. Ross, and 2 miles SSW of Hedgepeth Lake on private road into McKenzie Creek drainage; NW 1/4 Sec. 28, T. 9 N., R. 12 W. on a steep middle slope (64 percent) west aspect 1350 feet elevation: annual grass vegetation.

Range in Characteristics: Colors are normally 10YR hue throughout; schist phases commonly have 2.5Y hues. Horizonation is indistinct and structure is generally weak. Generally there is a slight clay increase with depth. Reaction changes little with depth but in places it becomes less acid with depth. The base saturation is generally under 70 percent and cation exchange capacity under 20 me per 100 gms of clay. Depth to fractured, weathered bedrock ranges from 20 to 32 inches. The A horizons range in color from grayish brown or light brownish gray (10YR) to brown (10YR); in texture from heavy loam to clay loam which may be gravelly; and in reaction from medium acid to strongly acid. The C horizons range from grayish brown or light brownish gray (10YR) to yellowish brown or light yellowish brown (10YR); in texture from non-gravelly to gravelly loams or clay loams with gravel fragments tending to increase in amount and size to bedrock; and in reaction from medium acid to strongly acid. Parent rock is usually medium grained, hard sandstone (graywacke), but includes conglomerate and schist which are mapped as phases.

Competing Series and Their Differentiae: These include the Hugo, Millsholm, Gaviota, Hulls, Kneeland, Maymen, Lodo, and Cahto soil series. The Hugo

soils are deep, gravelly, and have ochric epipedons and cambic horizons. The Millsholm soils have ochric epipedons, have slightly acid to neutral cambic horizons, a fine silty control section, a base saturation greater than 80 percent, and are in a thermic family. The Gaviota soils are slightly acid to neutral, have sandy loam textures (18 percent clay), and are in a thermic family. Hulls soils, derived from sericite schist, are micaceous, have mollic epipedons, and are medium to slightly acid in C horizons. Kneeland soils have thick dark grayish brown mollic epipedons contrasting sharply with pale brown cambic B horizons. Maymen soils are very shallow, have ochric epipedons and coarse loamy control sections. The Lodo soils, derived from highly fractured shales are slightly acid, are very shallow and lack cambic horizons, have base saturation greater than 80 percent, and are in a thermic family. The Cahto soils have thick very dark mollic epipedon and are slightly to medium acid throughout.

Setting: Laughlin soils occur on steep, strongly dissected mountains with narrow ridges and V-shaped drainages under grass and grass-oak vegetation. The soils are underlain by hard sandstone and shale (graywacke) of the Franciscan geological formation. They range from near sea level to about 3,500 feet elevation in a humid, mesothermal climate with warm to cool, nearly rainless summers, and cool, wet winters. Annual precipitation ranges from 40-80 inches. Mean annual temperature is about 59 F.; January average about 46 F.; July average about 69 F.; frost free season about 200-300 days.

Principal Associated Soils: Laughlin soils occur in the same general area as the forested soils Hugo and Josephine; the shrub covered soils Maymen and Los Gatos; and the grass covered soils Sutherlin, Yorkville, and McMahon.

Drainage and Permeability: Well drained, runoff moderate to rapid, permeability moderate to moderately rapid. Erodibility moderate.

Use and Vegetation: Woodland-grass or grass; dominantly annual grasses and forbs with open stands of Oregon white oak, blue oak, and some California black oak, laurel and madrone. Occasionally common manzanita may occur as understory under the hardwoods. Principal use is for range forage; some small areas may be harvested for hay.

Distribution and Extent: Lower slopes of the outer Coast Range mountains in northwestern California. The series is extensive with an area of about 500,000 acres.

Series Established: Soil-Vegetation Survey of Mendocino County, California 1948. Name from Laughlin Ridge, 8 miles SE of Willits, Mendocino County, California.

Remarks: The Laughlin series was formerly classified in the Regosol group. The soils have an umbric epipedon. The defined color range for Laughlin includes some Typic Ustochrepts. In early surveys Laughlin soils were included in the Hugo series. Hugo was redefined and limited to deep forested

soils with cambic horizons. Laughlin was defined and limited to moderately deep woodland-grass soils without cambic horizons. Large areas mapped Laughlin in Mendocino and Sonoma Counties in earlier surveys are complexes of Laughlin-Sutherlin and some Yorkville soils.

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## LOS GATOS SERIES

The Los Gatos series is a member of the fine-loamy, mixed, mesic family of Typic Argixerolls. Typically, Los Gatos soils have brown, light clay loam granular, slightly acid A1 horizons over brown and yellowish red slight and medium acid clay loam and gravelly clay loam, Bt horizons that rest on sandstone bedrock at depth of about 36 inches.

Typifying Pedon: Los Gatos clay loam - annual grass and brush  
(Colors are for dry soil unless otherwise noted.)

- A1 0-6"--Brown (7.5YR 5/4) light clay loam, dark brown (7.5YR 3/3) moist; strong medium granular structure; hard, friable, slightly sticky, slightly plastic; common very fine roots; many fine and very fine interstitial, few medium tubular pores; many worm casts and rodent burrows; slightly acid (pH 6.5); clear smooth boundary. (4 to 6 inches thick)
- A12 6-15"--Brown (7.5YR 5/4) light clay loam, dark brown (7.5YR 3/3) moist; moderate medium subangular blocky structure; hard, friable, slightly sticky, slightly plastic; few very fine roots; many fine and very fine interstitial and tubular, few medium tubular pores; common worm casts and rodent burrows; slightly acid (pH 6.3); clear smooth boundary. (7 to 11 inches thick)
- B1t 15-25"--Brown (7.5YR 5/4) clay loam, dark brown (7.5YR 3/3) moist; moderate medium subangular blocky structure; hard, friable, slightly sticky, slightly plastic; few very fine roots; many fine and very fine interstitial, tubular and few medium tubular pores; many thin clay films lining pores and on surfaces of peds; slightly acid (pH 6.2); abrupt wavy boundary. (9 to 12 inches thick)
- B2t 25-36"--Yellowish red (5YR 5/6) gravelly clean loam, reddish brown (5YR 4/5) moist; weak medium angular blocky structure; very hard, firm, sticky, plastic; few medium and fine roots; many very fine interstitial, tubular and few fine and medium tubular pores; thin about 15 percent medium and fine shale fragments; medium acid (pH 5.9); abrupt wavy boundary. (8 to 12 inches thick)
- R 36-46"--Very pale brown (10YR 7/4) sandstone with reddish brown (5YR 4/4) clay films on faces of peds; shattered in upper few inches becoming nearly massive within 10 inches.

Type Location: Santa Clara County, California; road cut on Monte Bello Road, 1 1/2 miles southeast of Black Mountain on the crest of Monte Bello Ridge; southern part of the SW1/4SE1/4 of sec. 19, T7S., R2W.

Range in Characteristics: Depth to a lithic contact is 24 to 40 inches. The soil between the depths of about 5 and 12 inches usually is dry all of the time from sometime in May until sometime in October. It usually is moist all the rest of the year. The mean annual soil temperature at a depth of 20 inches is 54° to 58°F. and the soil temperature is very briefly, if ever, below 47°F. Typically, there are few rock fragments in the solum ranges from slightly to medium acid. Typically, the A horizons are slightly acid and the B horizons are medium acid. The A horizon is fine sandy loam, loam or clay loam. It has granular or subangular blocky structure or has crumb structure in the upper part. The lower boundary of the A1 horizon is gradual or an A3 horizon or a B1 horizon is present. The organic matter content ranges from 2 to 6 percent. The B2t horizon is brown, strong brown, or light brown in 7.5YR hue or reddish brown or yellowish red in 5YR hue. It is heavy loam, sandy clay loam, or clay loam with less than 35 percent clay. Absolute clay increase from A horizon to B2t horizon ranges from about 5 to about 9 percent. The Bt horizon has weak to moderate subangular blocky structure. In some pedons, it rests on bedrock. In other pedons, there is a brownish yellow or yellowish brown B3 horizon or a C horizon above the bedrock.

Competing Series and their Differentiae: These are the Colma, Dagoon, Gilroy, Glenrose, Ladd, Lobitos, Los Osos, Mehlhorn, Sobrante, and Sweeney series. Colma, Lobitos, and Sweeney soils lack brown and reddish color of 7.5YR and 5YR hue in the Bt horizon. Colma, Dagoon, Glenrose, Ladd, and Sweeney soils lack a lithic contact at depths of less than 40 inches. Gilroy soils have a mean soil temperature of 59° to 64°F. Los Osos soils have more than 35 percent clay in the argillic horizon. Mehlhorn soils have a mean soil temperature of less than 54°F. Sobrante soils lack a mollic epipedon.

Setting: Los Gatos soils are on steep to very steep mountainous areas as elevation of 600 to 4,000 feet. The climate is subhumid mesothermal with warm dry summers and cool moist winters. Mean annual precipitation is 25 to 70 inches. The mean annual temperature is about 52° to 56°F. with an average January temperature of about 47°F and an average July temperature of about 68°F. Average freeze-free season is about 200 to 300 days.

Principal Associated Soils: These are the Camboa, Godde, Henneke, Maymen, Millsholm, Plaskett, and Sur series. All of these except the Henneke soils lack an argillic horizon. Gamboa, Henneke, Plasket, and Sur soils have more than 35 percent rock fragments in the texture control section. Godde soils have bedrock at depths of less than 20 inches. Maymen and Millsholm soils have ochric epipedons.

Drainage and Permeability: Well drained; rapid to very rapid runoff; moderate or moderately slow permeability.

Use and Vegetation: Most areas are used for watershed or wildlife protection. Some areas are used for range and a few of the lesser sloping areas have been planted to orchards and vineyards. Brush is the principal vegetation with some areas of hardwoods and grass.

Distribution and Extent: Coast Ranges of northern and central California. The soils are extensive.

Series Established: Santa Clara County (Santa Clara Area), California, 1946.

Remarks: The soils were formerly classified as (minimal) Brunizems. Some soils classified as Los Gatos in the past are in the thermic family and are now excluded from the series.

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## MAYMEN SERIES

The Maymen series is a member of the loamy, mixed, mesic family of Dystric Lithic Xerochrepts. Typically, Maymen soils have brown, medium acid, gravelly sandy loam A horizons and light yellowish brown, strongly acid, gravelly loam B2 horizons overlying bedrock at shallow depths.

Typifying Pedon: Maymen gravelly sandy loam -- chaparral  
(Colors are for dry soil unless otherwise noted.)

- 01 1-0"--Undecomposed leaves, 1/2 to 2-1/2 inches thick.
- A1 0-3"--Brown (10YR 5/3) gravelly sandy loam, dark brown (10YR 3/3) moist; moderate very fine granular structure; soft, very friable; few fine and very fine woody roots; many fine and very fine pores; about 6 percent angular and subangular rock fragments 1/2 to 2 inches in diameter; medium acid (pH 5.8); clear smooth boundary.  
(0 to 6 inches thick)
- B2 3-15"--Light yellowish brown (10YR 6/4) gravelly loam, yellowish brown (10YR 5/5) moist; moderate very fine granular structure; slightly hard, friable, slightly plastic, slightly sticky; common fine and medium woody roots; very porous with many fine and very fine pores; rock fragments as above; few thin discontinuous clay films line pores; strongly acid (pH 5/4); clear wavy boundary.  
(3 to 14 inches thick)
- R 15-60"--Light yellowish brown (10YR 6/4) and pale brown (10YR 6/3) fractured sandstone; very hard, becoming harder and less fractured with increasing depth; few large woody roots to 60 inches. (many feet thick)

Type Location: Santa Clara County, California; Loma Chiquita, 1 1/4 miles southeast of Loma Prieta.

Range in Characteristics: Depth to bedrock ranges from 10 to 20 inches. The mean soil temperature just above bedrock is between 48 and 58°F. and is above 47 degrees F. in most pedons except for periods in January and February. These soils are usually continually moist, but are dry throughout from mid-May or June until sometime in September. They are medium to strongly acid and tend to become more acid with depth. Coarse fragments make up 10 to 35 percent of the soil, but most pedons have 20 to 30 percent. The A horizon is grayish brown, dark grayish brown, brown, pale brown, light brown, or light brownish gray, in 10YR or 7.5YR hue. The dark layers are thin or absent in eroded pedons. A horizon is sandy loam or loam and is usually gravelly. The B horizon is pale brown, light brown, light yellowish brown, or reddish yellow. It has weak or moderate granular or subangular blocky structure; or it has a slight textural increase over the A horizon and contains a few clay films. It is loam with between 15 and 18 percent clay. It has 40 to 60 percent base saturation.

Competing Series and their Differentiae: These are the Amargosa, Daulton, Exchequer, Gaviota, Hideaway, Hornitos, McCarthy, Neuns, Toomes and Yollabolly soils. Amargosa, Exchequer and Gaviota soils lack cambic horizons and have a mean soil temperature above 59°F. Daulton, Hornitos, and Toomes soils have a mean soil temperature above 59°F. Hideaway soils are less than 10 inches thick and have more than 35 percent coarse fragments. McCarthy and Neuns soils have more than 35 percent coarse fragments. Yollabolly soils have a mean temperature of less than 47°F.

Setting: The Maymen soils occur on mountainous uplands with steep to very steep slopes at elevations of 1,000 to 4,000 feet. Underlying bedrock is consolidated sandstone, shale, and conglomerate. Climate is moist subhumid with a mean annual precipitation of 25 to 60 inches with warm, dry summers and cool, moist winters. Average January temperature is 47°F., average July temperature is about 68°F. and mean annual temperature is about 55° to 57°F. The average frost-free season is 200 to 300 days.

Principal Associated Soils: These are the Hugo, Josephine, Laughlin, Los Gatos, Mariposa, and Sheetiron soils and the competing Gaviota soils. Hugo, Josephine, Laughlin, Los Gatos, and Sheetiron soils are more than 30 inches deep to rock. Mariposa soils have an argillic horizon in a part of each pedon.

Drainage and Permeability: Well or somewhat excessively drained; rapid to very rapid; moderate or moderately rapid permeability.

Use and Vegetation: Used mainly for watershed, wildlife and recreation. Vegetation is usually open stands of chaparral consisting of chamise, manzanita, several species of ceanothus, several species of scrub or dwarf oak, and scattered small trees in protected sites.

Distribution and Extent: Coast Ranges and western slopes of the Sierra Nevada of California.

Series Established: Santa Barbara County, California, 1945.

Remarks: The soils are formerly classified as Lithosols.

National Cooperative Soil Survey  
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## YORKVILLE SERIES

The Yorkville series is a member of the fine, chloritic, mesic family of Pachic Argixerolls. Typically, Yorkville soils have grayish brown, medium acid, loam A horizons, grayish brown, and dark grayish brown, slightly acid, clay loam and clay Bt horizons, underlain by dark gray, clay C horizons over broken graywacke.

Typifying Pedon: Yorkville loam - grassland  
(Colors are for dry soil unless otherwise noted.)

- All 0-8"--Grayish brown (2.5Y 5/2) loam, very dark grayish brown (2.5Y 3/2) moist; moderate coarse subangular blocky structure; hard, friable, sticky, plastic; many very fine and fine roots; many very fine and fine tubular and interstitial pores; medium acid; diffuse smooth boundary. (6 to 10 inches thick)
- Al2 8-14"--Grayish brown (2.5Y 5/2) heavy loam, very dark grayish brown (2.5Y 3/2) moist; moderate coarse subangular blocky structure; hard, friable, sticky, plastic; many very fine and fine tubular and interstitial pores; medium acid; clear smooth boundary. (6 to 10 inches thick)
- B2lt 14-19"--Grayish brown (2.5Y 5/2) clay loam, very dark grayish brown (2.5Y 3/2) moist; moderate medium subangular blocky structure; hard, firm, sticky, plastic; common very fine and fine roots; many very fine and fine tubular pores; many moderately thick clay films as bridges, and on faces of peds; slightly acid; clear wavy boundary. (4 to 6 inches thick)
- B22t 19-32"--Dark grayish brown (2.5Y 4/2) clay, very dark grayish brown (2.5Y 3/2) moist; moderate medium subangular blocky structure; extremely hard, firm, sticky, very plastic; few very fine roots; many very fine tubular pores; many moderately thick clay films as bridges, and on faces of peds; slightly acid; clear wavy boundary. (12 to 18 inches thick)
- C1 32-60"--Dark gray (5Y 4/1), dry and moist, clay; strong coarse and very coarse angular blocky structure; extremely hard, firm, very sticky, very plastic; few very fine roots; common very fine tubular pores; many pressure faces; few thin clay films on faces of peds; moderately alkaline; gradual boundary. (12 to 28 inches thick)
- C2 60-70"--Fault gouge consisting of fractured graywacke and chlorite schist with dense clay filling joints.

## Yorkville Series

Type Location: Sonoma County, California; 2.5 miles SSW of Hedgepeth Lake, 0.2 miles south of Ward Creek Road, on private road to McKenzie Creek; NW1/4 sec. 28, T.9N., R.12W.

Range in Characteristics: Depth to a paralithic contact is 40 to 70 inches. Usually the soil between depth of about 4 and 12 inches is moist all of the time from sometime in October until sometime in June and is dry all of the rest of the year. The mean annual soil temperature is 54° to 57° F. Coarse fragments make up 5 to 35 percent of the profile, but usually there is less than 10 percent except in the horizons near the bottom of the profile. Base saturation is 75 to 100 percent throughout the profile. Organic matter content is 4 to 8 percent and is more than 1 1/2 percent to a depth of more than 20 inches. The A horizon is gray, grayish brown or dark grayish brown in 10YR, 2.5Y or 5Y hue. Its lower boundary is clear or gradual. This horizon is neutral to medium acid. The B2t horizon is dark grayish brown, grayish brown, brown or olive brown in 10YR or 2.5Y hue, or olive or gray in 5Y hue. It is clay loam or clay and averages 35 to 45 percent clay. This horizon is usually medium to slightly acid in the upper part or in all parts, but is neutral or mildly alkaline in the lower part of some pedons. Slickensides are present in some pedons, usually in the lower part of the B2t horizon or in horizons transitional to the parent materials. Common faint mottles or a few distinct mottles are present in some pedons. The C horizon, or B3 horizon if present, is similar in color and texture to the B2t horizon. It usually contains more coarse fragments and less clay than the B2t horizon. This horizon may have few to common slickensides. It is neutral to moderately alkaline and has some secondary lime in some pedons.

Competing Series and their Differentiae: These are the Coburg, Dixonville, Jackknife, Keating, Kneeland, Malabon, and Mindego series. Coburg, Dixonville and Malabon soils have mixed mineralogy and less than 75 percent base saturation in the upper 30 inches of the profile. Jackknife and Mindego soils have montmorillonitic mineralogy. Keating soils have a mollic epipedon less than 20 inches thick. Kneeland soils lack an argillic horizon, and have less than 35 percent clay in the control section.

Setting: Yorkville soils are on hilly to very steep slopes at elevations of 500 to 4,000 feet. Slopes are unstable, very complex and marked by slides, humps and wet spots. The soils formed in residuum weathered from chlorite schists, graywacke and similar metamorphosed rocks. The climate is humid to subhumid mesothermal with cool wet winters and dry cool summers. Average January temperature is about 47°F., average July temperature is about 57° to 62°F., and mean annual temperature is about 50° to 55° F. The frost-free season is about 200 to 260 days.

Principal Associated Soils: These are the Hugo, Laughlin, Madonna, Sutherlin, and Tyson soils and the competing Kneeland soils. Hugo and Madonna soils have ochric epipedons and lack argillic horizons. Laughlin soils are less than 40 inches deep to bedrock. Sutherlin soils have an ochric epipedon and an abrupt upper boundary in the argillic horizon. Tyson soils have more than 35 percent coarse fragments.

Yorkville Series

Drainage and Permeability: Moderately well-drained; medium to very rapid runoff; slow permeability.

Use and Vegetation: Used for grazing. Vegetation is annual and perennial grasses and some forbs.

Distribution and Extent: Northern California in the Coast Ranges. The soils are of moderate extent.

Series Established: Mendocino County, California, 1952.

Remarks: The Yorkville soils were formerly classified as Brunizems.

National Cooperative Soil Survey  
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VegetationGRASSES AND GRASSLIKE PLANTS

1. Annual Bluegrass (*Poa annua*)
2. Bermudagrass (*Cynodon dactylon*)
3. Blue wildrye (*Elymus glaucus*)
4. California medic (*Melica californica*)
5. Dogtail (*Cynosurus echinatus*)
6. Foxtail fescue (*Festuca megalura*)
7. Little quaking grass (*Briza minor*)
8. Mediterranean barley (*Hordeum hystrix*)
9. Medusa-head (*Elymus caput-medusae*)
10. Nitgrass (*Gastridium ventricosum*)
11. Pine bluegrass (*Poa scarbrella*)
12. Red brome (*Bromus rubens*)
13. Ripgut grass (*Bromus rigidus*)
14. Rush (*Juncus* spp.)
15. Sedge (*Carex* spp.)
16. Silver hairgrass (*Aira caryophyllea*)
17. Slender oat (*Avena barbata*)
18. Soft chess (*Bromus mollis*)
19. Squirreltail (*Sitanion jubatum*)

FORBS

1. Fiddleneck (*Amsinckia intermedia*)
2. Bedstraw (*Galium californicum*)
3. Brodia (*Brodiaea pulchella*)
4. Brodia (*Brodiaea laxa*)
5. Bur clover (*Medicago hispida*)
6. California poppy (*Eschscholtzia californica*)
7. Common fennel (*Foeniculum vulgare*)
8. Coyote mint (*Monardella villosa*)
9. Goldfields (*Baeria chrysostoma*)
10. Gold wire (*Hypericum concinnum*)
11. Hedge Nettle (*Stachys* spp.)
12. Hedge parsley (*Torilis nodosa*)
13. Italian thistle (*Carduus pycnocephalus* or *tenuiflorus*)
14. Lupines (*Lupinus* spp.)
15. Monkey flower (*Mimulus guttatus*)
16. Monkey flower (*Mimulus* spp.)
17. Mullein (*Verbascum thapsis*)
18. Napa thistle (*Centaurea melitensis*)
19. Owl's clover (*Orthocarpus* spp.)
20. Popcorn flower (*Plagiobothrys* spp.)

21. Smooth car-ear (*Hypochoeris glabra*)
22. Ture clovers (*Trifolium* spp.)
23. Turkey mullein (*Eremocarpus setigerus*)
24. Wooly Indian paintbrush (*Castilleja foliolosa*)
25. Mules-ear (*Wyethia glabra*)

#### SHRUBS

1. Bracken fern (*Pteridium aquilinum*)
2. Buckbrush (*Ceanothus cuneatus*)
3. Buckweat (*Eriogonum* spp.)
4. Bush monkeyflower (*Pioplacus aurantiacus*)
5. Bush poppy (*Dendromecon rigida*)
6. Chamise (*Adenostoma fasciculatum*)
7. Coffeeberry (*Rhamnus californica*)
8. Coyote Brush (*Baccharis pilularis*)
9. Deer brush (*Ceanothus integerrimus*)
10. Poison Oak (*Rhus diversiloba*)
11. Redberry (*Rhamnus crocea*)
12. Shrub chinquapin (*Castanopsis chrysophylla*)
13. Toyon (*Photinia arbutifolia*)
14. Wavyleaf ceanothus (*Ceanothus foliosus*)
15. Western mountain mahogany (*Cercocarpus betuloides*)
16. Yerba santa (*Eriodictyon californicum*)

#### TREES

1. Bigleaf maple (*Acer macrophyllum*)
2. Black oak (*Quercus kelloggii*)
3. Blue oak (*Quercus douglasii*)
4. California buckeye (*Aesculus californica*)
5. California laurel (*Umbellularia californica*)
6. Digger pine (*Pinus sabiniana*)
7. Douglas-fir (*Pseudotsuga menziessi*)
8. Incense cedar (*Libocedrus decurrens*)
9. Interior liveoak (*Quercus wislizenii*)
10. Knobcone pine (*Pinus attenuata*)
11. Leather oak (*Quercus durata*)
12. Madrone (*Arbutus menziesii*)
13. Pacific dogwood (*Cornus nuttallii*)
14. Ponderosa pine (*Pinus ponderosa*)
15. Sargent cypress (*Cupressus sargentii*)
16. Scrub oak (*Quercus dumosa*)
17. Shrubby Canyon live oak (*Quercus chrysolepis*)
18. Sugar pine (*Pinus lambertiana*)
19. Valley oak (*Quercus lobata*)

Wildlife Inventory of the Cow Mountain  
Planning Unit, Lake County

Turtles

Pacific mud turtle  
(Western pond turtle)  
Clemmys marmorata

Lizards

Northwestern fence lizard  
Sceloporus occidentalis

Western skink  
Eumeces shiltonianus

Southern alligator lizard  
Gerrhonotus multicarinatus

Western whiptail  
Cnemidophorus tigris

Northern Sagebrush lizard  
Sceloporus graciosus

Snakes

Sharp-tailed snake  
Contia tenuis

Western yellow-bellied racer  
Coluber constrictor

Common king snake  
Lampropeltis getulus

Common gartersnake  
Thamnophis sirtalis

Western rattlesnake  
Crotalus viridis

Rubber boa  
Charina bottae

N.W. Ringneck snake  
Diadophis punctatus

Snakes (cont.)

Pacific gopher snake  
Pituophis melanoleucus

California mtn. kingsnake  
Lampropeltis zonata

Western long-nosed snake  
Rhinocheilus lecontei

Western terr. gartersnake  
Thamnophis elegans

Western aquatic gartersnake  
Thamnophis couchi

Striped racer  
Masticophis lateralis

Amphibians

Pacific giant salamander  
Dicamptodon ensatus

Northern rough-skinned newt  
Taricha granulosa

Western red-bellied newt  
Taricha rivularis

Ensatina  
Ensatina eschscholtzi

California newt  
Taricha torosa

Cal. slender salamander  
Batrachoseps attenuatus

Speckled black salamander  
Aneides flavipunctatus

Clouded salamander  
Aneides ferreus

Amphibians (continued)

Aboreal salamander

Aneides lugubris

Brown N.W. salamander

Ambystoma gracile

Southern olympic salamander

Rhyacotriton olympicus

Western toad

Bufo boreas

Pacific tree frog

Hyla regilla

Red-legged frog

Rana aurora

Foothill yellow-legged frog

Rana boylei

Bull frog

Rana catesbeiana

Tailed frog

Ascaphus truei

Mammals

Opposum

Didelphis marsupialis

Towbridge Shrew

Sorex towbridgei

Vagrant Shrew

Sorex vagrans

Shrew-mole

Neurotrichus gibbsi

Pacific mole

Scapanus orarius

California mole

(Broad-handed)

Scapanus latimanus

Mammals (cont.)

Little Brown Myotis

Myotis lucifugus

Yuma myotis

Myotis yumanensis

Long-eared myotis

Myotis evotis

Fringed myotis

Myotis thysanodes

Long-legged myotis

Myotis volans

California myotis

Myotis californicus

Silver-haired bat

Lasionycteris noctivagans

Big brown bat

Eptesicus fuscus

Red bat

Lasiurus borealis

Hoary bat

Lasiurus cinereus

Western big-eared bat

Plecotus townsendi

Pallid bat

Antrozous pallidus

Mexican freetail bat

Tadarida brasiliensis

Black bear

Ursus americanus

Raccoon

Procyon lotor

Ringtail

Bassariscus astutus

Mammals (Continued)

Fisher

Martes pennanti

Shorttail weasel

Mustela erminea

Longtail weasel

Mustela frenata

Mink

Mustela vison

Badger

Taxidea taxus

Spotted skunk

Spilogale putorius

Striped skunk

Mephitis mephitis

Coyote

Canis Latrans

Gray fox

Urocyon cinereoargenteus

Mountain lion

Felis concolor

Bobcat

Lynx rufus

Wild boar

Sus scrofa

California ground squirrel

Citellus beecheyi

Townsend chipmunk

Eutamias townsendi

Sonoma chipmunk

Eutamias sonomae

Western gray squirrel

Sciurus griseus

Valley pocket gopher

Thomomys bottae

Mammals (Continued)

Heermann kangaroo rat

Dipodomys heermanni

Western harvest mouse

Reithrodontomys megalotis

Deer mouse

Peromyscus maniculatus

Brush mouse

Peromyscus boylei

Pinon mouse

Peromyscus truei

Dusky-footed woodrat

Neotoma fuscipes

Tree phenacomys

Phenacomys longicaudus

Calif. redback vole

Clethrionomys occidentalis

California vole

Microtus californicus

Muskrat

Ondatra zibethica

House mouse

Musa musculus

Pacific jumping

Zapus trinotatus

Porcupine

Erethizon dorsatum

Blacktail jackrabbit

Lepus californicus

Brush rabbit

Sylvilagus bachmani

Black-tailed deer

Odocoileus hemionus columbianus

Birds

Common Loon  
Gavia immer

Eared grebe  
Podiceps caspicus

Western grebe  
Aechmophorus occidentalis

Pied-Billed grebe  
Podilymbus podiceps

White pelican  
Pelecanus erythrorhynchos

Double-crested cormorant  
Phalacrocorax auritus

Great Blue heron  
Ardea herodias

Whistling swan  
Olor columbianus

Trumpeter swan  
Olor buccinator

Canada goose  
Branta canadensis

Black brant  
Branta nigricans

White-fronted goose  
Anser albifrons

Snow goose  
Chen hyperborea

Mallard  
Anas platyrhynchos

Gadwall  
Anas strepera

Pintail  
Anas acuta

Birds (Cont.)

Green-winged teal  
Anas carolinensis

Cinnamon teal  
Anas cyanoptera

American widgeon  
Mareca americana

Shoveler  
Spatula clypeata

Wood duck  
Aix sponsa

Redhead  
Aythya americana

Ring-necked duck  
Aythya collaris

Greater scaup  
Aythya marila

Lesser scaup  
Aythya affinis

Common goldeneye  
Bucephala clangula

Bufflehead  
Bucephala albeola

White-winged scoter  
Melanitta deglandi

Ruddy duck  
Oxyura jamaicensis

Hooded merganser  
Lophodytes cucullatus

Common merganser  
Mergus merganser

Turkey vulture  
Cathartes aura

Birds (Continued)

White-tailed kite  
Elanus leucurus

Goshawk  
Accipiter gentilis

Sharp-shinned hawk  
Accipiter striatus

Cooper's hawk  
Accipiter cooperii

Red-tailed hawk  
Buteo jamaicensis

Red-shouldered hawk  
Buteo lineatus

Swainson's hawk  
Buteo swainsoni

Ferruginous hawk  
Buteo regalis

Golden eagle  
Aquila chrysaetos

Bald eagle  
Haliaeetus leucocephalus

Marsh hawk  
Circus cyaneus

Osprey  
Pandion haliaetus

Peregrine falcon  
Falco peregrinus

Pigeon hawk (Merlin)  
Falco columbarius

Sparrow hawk  
Falco sparverius

California quail  
Lophortyx californicus

Mountain quail  
Oreortyx pictus

Birds (Continued)

Ring-necked pheasant  
Phasianus colchicus

Virginia rail  
Rallus limicola

Sora  
Porzana carolina

Common gallinule  
Gallinula chloropus

American coot  
Fulica americana

Killdeer  
Charadrius vociferus

Common snipe  
Capella gallinago

Spotted sandpiper  
Actitis macularia

Solitary sandpiper  
Tringa solitaria

Greater yellowlegs  
Totanus melanoleucus

Lesser yellowlegs  
Totanus flavipes

Least sandpiper  
Erolia minutilla

Short-billed dowitcher  
Limnodromus griseus

Long-billed dowitcher  
Limnodromus scolopaceus

Western sandpiper  
Ereunetes mauri

Northern phalarope  
Lobipes lobatus

Glaucous-winged gull  
Larus glaucescens

Birds (Continued)

Herring gull  
Larus argentatus

California gull  
Larus californicus

Ring-billed guss  
Larus delawarensis

Band-tailed pigeon  
Columba fasciata

Mourning dove  
Zenaidura macroura

Roadrunner  
Geococcyx californianus

Barn owl  
Tyto alba

Screech owl  
Otus asio

Flammulated owl  
Otus flammeolus

Great horned owl  
Bubo virginianus

Pygmy owl  
Glaucidium gnoma

Spotted owl  
Strix occidentalis

Great gray owl  
Strix nebulosa

Poor-will  
Phalaenoptilus nuttallii

Common nighthawk  
Chordeiles minor

Vaux's swift  
Chaetura vauxi

Birds (Continued)

White-throated swift  
Aeronautes saxatalis

Black-chinned hummingbird  
Archilochus alexandri

Anna's hummingbird  
Calypte anna

Rufous hummingbird  
Selasphorus rufus

Allen's hummingbird  
Selasphorus sasin

Calliope hummingbird  
Stellula calliope

Belted kingfisher  
Megaceryle alcyon

Yellow-shafted flicker  
Colaptes auratus

Red-shafted flicker  
Colaptes auratus

Red-shafted flicker  
Colaptes cafer

Pileated woodpecker  
Dryocopus pileatus

Acorn woodpecker  
Melanerpes formicivorus

Lewis' woodpecker  
Asyndesmus lewis

Yellow-bellied sapsucker  
Sphyrapicus varius

Hairy woodpecker  
Dendrocopos villosus

Downy woodpecker  
Dendrocopos pubescens

Birds (Continued)

Nuttall's woodpecker  
Dendrocopos nuttallii

White-headed woodpecker  
Dendrocopos albolarvatus

Eastern kingbird  
Tyrannus tyrannus

Western kingbird  
Tyrannus verticalis

Ash-throated flycatcher  
Myiarchus cinerascens

Black phoebe  
Sayornis nigricans

Say's phoebe  
Sayornis saya

Traill's flycatcher  
Empidonax traillii

Hammond's flycatcher  
Empidonax hammondii

Western flycatcher  
Empidonax difficilis

Western wood pewee  
Contopus sordidulus

Olive-sided flycatcher  
Nuttallornis borealis

Horned lark  
Eremophila alpestris

Barn swallow  
Hirundo rustica

Cliff swallow  
Petrochelidon pyrrhonota

Purple martin  
Progne subis

Steller's jay  
Cyanocitta stelleri

Birds (Continued)

Scrub jay  
Aphelocoma coerulescens

Common raven  
Corvus corax

Common crow  
corvus brachyrhynchos

Clark's nutcracker  
Nucifraga columbiana

Mountain chickadee  
Parus gambeli

Chestnut-backed chickadee  
Parus rufescens

Plain titmouse  
Parus inornatus

Common titmouse  
Parus wollweberi

White-breasted nuthatch  
Sitta carolinensis

Red-breasted nuthatch  
Sitta canadensis

Pygmy nuthatch  
Sitta pygmaea

Brown creeper  
Certhia familiaris

Wrentit  
Chamaea fasciata

Dipper  
Cinclus mexicanus

House wren  
Troglodytes aedon

Winter wren  
Troglodytes troglodytes

Bewick's wren  
Thryomanes bewickii

Birds (Continued)

Long-billed marsh wren  
Telmatodytes palustris

Canon wren  
Catherpes mexicanus

Rock wren  
Catherpes mexicanus

Mockingbird  
Minus polyglottos

California thrasher  
Toxostoma redivivum

Robin  
Turdus migratorius

Varied thrush  
Ixoreus naevius

Hermit thrush  
Hylocichla guttata

Swainson's thrush  
Hylocichla ustulata

Western bluebird  
Sialia mexicana

Mountain bluebird  
Sialia currucoides

Blue-gray gnatcatcher  
Polioptila caerulea

Golden-crowned kinglet  
Regulus satrapa

Ruby-crowned kinglet  
Regulus calendula

Water pipit  
American pipit

Cedar waxwing  
Bombycilla cedrorum

Birds (Continued)

Loggerhead shrike  
Lanius ludovicianus

Starling  
Sturnus vulgaris

Hutton's vireo  
Vireo huttoni

Bell's vireo  
Vireo bellii

Solitary vireo  
Vireo solitarius

Warbling vireo  
Vireo gilvus

Orange-crowned warbler  
Vermivora celata

Nashville warbler  
Vermivora ruficapilla

Yellow warbler  
Dendroica petechia

Myrtle warbler  
dendroica coronata

Black-throated gray warbler  
Dendroica nigrescens

Townsend's warbler  
Dendroica townsendi

Hermit warbler  
Dendroica occidentalis

MacGillivray's warbler  
Oporornis tolmiei

Yellowthroat  
Geothlypis trichas

Yellow-breasted chat  
Icteria virens

Birds (Continued)

Wilson's warbler  
Wilsonia pusilla

House sparrow  
Passer domesticus

Western meadowlark  
Sturnella neglecta

Yellow-headed blackbird  
Xanthocephalus xanthocephalus

Red-winged blackbird  
Agelaius phoeniceus

Tricolored blackbird  
Agelaius tricolor

Brewer's blackbird  
Euphagus cyanocephalus

Brown-headed cowbird  
Molothrus ater

Western tanager  
Piranga ludoviciana

Black-headed grosbeak  
Pheucticus melanocephalus

Lazuli bunting  
Passerina amoena

Purple finch  
Carpodacus purpureus

House finch  
Carpodacus mexicanus

Pine siskin  
Spinus pinus

American goldfinch  
Spinus tristis

Birds (Continued)

Lesser goldfinch  
Spinus psaltria

Lawrence's goldfinch  
Spinus lawrencei

Red crossbill  
Loxia curvirostra

Green-tailed towhee  
Chlorura chlorura

Rufous-sided towhee  
Pipilo erythrophthalmus

Brown towhee  
Pipilo fuscus

Savannah sparrow  
Passerculus sandwichensis

Grasshopper sparrow  
Ammodramus savannarum

Vesper sparrow  
Pooecetes gramineus

Lark sparrow  
Chondestes grammacus

Rufous-crowned sparrow  
Aimophila ruficeps

Sage sparrow  
Amphispiza belli

Slate-colored junco  
Junco hyemalis

Oregon junco  
Junco oreganus

Chipping sparrow  
Spizella passerina

Birds (Continued)

Black-chinned sparrow  
Spizella atrogularis

White-crowned sparrow  
Zonotrichia leucophrys

Golden-crowned sparrow  
Zonotrichia atricapilla

White-throated sparrow  
Zonotrichia albicollis

Fox sparrow  
Passerella iliaca

Lincoln's sparrow  
Melospiza lincolni

Song sparrow  
Melospiza melodia

## California Regional Water Quality Control Board

## North Coast Region

## Waste Discharge Requirements

## For

UNION OIL COMPANY OF CALIFORNIA  
The Geysers, Sonoma County

Order No. 70-4

October 29, 1970

The California Regional Water Quality Control Board, North Coast Region finds that:

1. Union Oil Company of California is the operator for itself, Magma Power Company, and Thermal Power Company on all matters at the Geysers including the disposal of condensate from Pacific Gas and Electric Company's Geysers Power Plant.
2. Present waste flow is approximately 1.0 mgd; however, Union Oil Company of California expects this flow to increase to 9.07 mgd by 1975.
3. All excess condensate is presently, and will continue to be, reinjected into the geothermal steam reservoir.
4. Union Oil Company of California is also developing the steam field which includes drilling and road building operations.
5. Beneficial uses of Big Sulphur Creek include: water-oriented recreation such as fishing, camping, and picnicking; a habitat for fish, aquatic life, and wild life; industrial water supply; and esthetic considerations associated with public and private recreational activities.
6. The discharge and land management activities have been subject to requirements issued by the Regional Board on September 4, 1968 for Pacific Gas and Electric Company, and on February 27, 1969, for Union Oil Company of California respectfully.
7. The Regional Board has notified the discharger and interested agencies and persons of its intent to revise its waste discharge requirements for this operation.
8. The Regional Board has reviewed the comments and recommendations of all concerned agencies and, in a public meeting on October 29, 1970, heard and considered the comments of all those present and desiring to be heard on the subject of the waste discharge requirements.

Therefore, it is hereby ordered that the Union Oil Company of California shall comply with the following:

(A) Waste Discharge Requirements

1. Neither the treatment nor disposal of waste shall cause a pollution or nuisance.
2. At no time shall any condensate from Pacific Gas & Electric Company's Geysers Power Plants reach the waters of Big Sulphur Creek or its tributaries.
3. At no time shall any drilling muds or any other waste materials from well drilling operations reach the waters of Big Sulphur Creek or its tributaries.
4. At no time shall any oil, petroleum products, or any other materials toxic or detrimental to human, plant, animal, or aquatic life reach the waters of Big Sulphur Creek or its tributaries.
5. Debris from road construction, road maintenance, or well drilling site construction shall be controlled so that it could not reasonably be expected to be carried into the waters of Big Sulphur Creek or its tributaries.
6. No phase of the operation shall increase the turbidity of the waters of Big Sulphur Creek or its tributaries more than 20 percent above unaffected upstream levels.

(B) Other Provisions

1. Union Oil Company of California shall comply with a monitoring and reporting program specified by the Executive Officer.
2. The discharge requirements shall be valid for waste discharges up to 9.07 million gallons per day.

Certification:

I, David C. Joseph, Executive Officer, do hereby certify that the foregoing is a full, true, and correct copy of an order adopted by the California Regional Water Quality Control Board, North Coast Region on October 29, 1970.

s/ D.C. Joseph  
David C. Joseph  
Executive Officer

# CONDITIONS, PROCEDURES, AND PERFORMANCE STANDARDS

## FOR

## GEOTHERMAL REGULATION

## COUNTY OF LAKE

ADOPTED AS POLICY

April 13, 1972

AMENDED AUGUST 24, 1972

LAKE COUNTY PLANNING COMMISSION

**HAHN, WISE and  
ASSOCIATES, INC.**  
1008 Laurel Street, San Carlos, California  
PLANNING CONSULTANTS

## DEFINITIONS

1. Operator means any person, firm, or corporation; drilling, maintaining, operating, pumping, or in control of any well or related facilities for mineral extraction, desalination or any other use of geothermal resources.
2. Test means to produce geothermal fluids and/or steam for a length of time, at a volume and rate accepted by the county and regional office, California Water Quality Control Board.
3. Test Facilities means lines, pumps, separators, metering facilities ponds and sumps used during the testing of a geothermal well or injection well.
4. Ground cover includes naturally growing trees, shrubs or grass.
5. Restricted area includes recreation homes areas and permanent home areas of two or more dwelling sites per acre; resort areas and other areas considered critical by the Planning Commission either because of development, potential development or ecology strip.
6. Landscaping Screen includes planting of native shrubs or plants or plant types suitable for the area and soil conditions which shall mature in three years or less.
7. Sound Level Measurement is the sound pressure level measured with a sound level meter and associated octave band analyzer, conforming to the standards prescribed by the United States of America Standards Institute Criteria relating to sound and noise measurements.

8. Proposal - A definite detailed proposal outlining the work to be done and how it would be integrated into a total geothermal development project must be submitted. The proposal must conform with all the conditions and standards which apply to geothermal development in the county.
9. Application reservation - The Planning Commission reserves the right to deny an application if it will not be compatible with the Existing or Land Use Element of the General Plan of the area.
10. Compliance with the law - The operator engaged in the drilling, production maintenance, and abandonment of geothermal wells and related facilities including the disposal of waste products shall comply with all applicable local, state, and federal laws and ordinances in effect or subsequently duly enacted.
11. Commencement of work - Prior to commencing any operation, all governmental conditions and standards applicable to the particular phase of work contemplated shall be complied with, including written approval of the District Office, California Regional Water Quality Control Office.
12. General compliance - All well drilling, plant construction, testing, and operations shall be conducted so as to be in harmony with the area and do not conflict with the public health, safety, comfort, convenience, general welfare and conditions of approval.
13. Master plan development - The operator shall cooperate with the county departments or the county's planning commission in the development of the Geothermal Element for the county's master plan.
14. Permit expiration - Abandonment of a project for six (6) months shall cause the permit, then in effect, to expire and to become null and void.
15. Timetable - A reasonable timetable for project development will be made a condition of any permits granted.
16. Bonds - Each operator shall file and furnish with the county an indemnity bond in the sum of \$5,000 for each well drilled or abandoned well re-entered or a blanket bond in the sum of \$25,000 for up to five wells drilled or re-entered. The bond will indemnify the county for any costs incurred by the county in repairing and reforesting any drill, test, or geothermal production facility site, to as near as possible to its original state and in abating any public nuisance caused by the principal's exploratory, testing, or producing operations.

17. Insurance - Before commencing or continuing any geothermal operations, the owner or operator shall show continuing evidence of insurance against liability in tort in a minimum amount of \$1,000,000 arising from the production activities or operations incident thereto conducted or carried on under, or by virtue of any law or ordinance. Such insurance shall be kept in full force and effect during the period of such operations.
18. Cleanup - Upon completion of any phase of the project, the site shall be cleaned up in accordance with the standards, and insofar as practical, the land returned to its original condition.
19. Waste disposal - All waste, whether liquid or solid, must be disposed of in compliance with the existing county, state, and federal rules and regulations. No waste shall be allowed to enter any streams, creek or other body of water.
20. Noise suppression - The operation of temporary or permanent equipment and all other operations performed on the premises shall be done in a manner so as to suppress all noise to acceptable levels as outlined in the State standards and as set forth in Ordinance 645 of the County.
21. Air pollution - Air pollution shall be maintained within the requirements acceptable by the County Ordinance No. 645 and other statutes dealing with air pollution.
22. Aesthetic requirements - All permanent installations and premises including power, steam, and/or fluid transmission lines shall be harmonious in appearance with the area and not of obnoxious, undesirable, or unsightly appearance. A landscaping screen shall be installed to the approval of the County Planning Commission.
23. Right of entry - The county reserves the right to enter the premises under the control of the operator of any geothermal operation to make appropriate inspections to determine if the conditions of this policy are being fulfilled.
24. Public facilities - If location or site of the proposed project is such as to require additional public access facilities, the operator shall be required to provide, where necessary, rights-of-way on property he controls and to provide the necessary road work. Any roads installed shall be dust-proofed to the satisfaction of the County Road Department.
25. Ground cover - The removal of ground cover during the construction of roads, well locations, test, and power sites must be in accordance with the accepted requirements of the County Planning Commission. All fill and cut banks shall be planted to the requirements of the County Planning Commission.

26. Earth works - All roads, well locations, test, and power plant sites must be made as small as possible, and all large cuts and/or fills will be replanted with a flora which is compatible with the indigenous environment and a planting plan shall be approved by the Planning Commission and maintained as a condition of approval.
27. Sumps and test ponds - Sumps and test ponds must be constructed in accordance with the requirements set forth in the standards adopted by the county and other pertinent agencies.
28. Subsidence - Any operator producing geothermal fluids for a permanent plant producing power, water, minerals, or other by products shall participate in a Geothermal subsidence prevention and detection program developed by the County and State Governments.
29. No geothermal well shall be drilled within one-half mile of any populated area (10 or more dwelling units established within one-quarter mile area) or within one-half mile of any recorded subdivision, without written consent of a minimum of 75% of the owners having been obtained.
30. Conditions requested by the State Division of Forestry shall be considered as a condition of the use permit.

## STANDARDS

### I. DRILLING STANDARDS

#### A. County-Wide Drilling Standards

1. All geothermal well sites shall have a sign having a surface of not less than 2 square feet and not more than 6 square feet bearing the current name and number of the well, and the name and/or insignia of the operator and the owner. This sign shall be displayed at all times from the commencement of drilling until the well has been abandoned.
2. All access roads into geothermal development areas shall have a sign located in a conspicuous place bearing the name and/or insignia of the operator and the current emergency telephone number of the operator's agent.
3. Within 60 days after the completion of the drilling of a well, all drilling wastes must be removed from the drilling site and disposed of, in accordance with the county and state water quality control regulations.
4. Drilling operations shall be diligently pursued until each well is completed or abandoned.
5. Prior to the commencement of drilling, re-drilling, re-working or abandonment of any geothermal well, it shall be the responsibility of the operator to comply with the State of California's geothermal resources laws as administered by the Division of Oil and Gas; any orders of the District Water Quality Control Office; any conditions imposed by the County or Division of Forestry.
6. Following the abandonment or completion of a well to production or waste water injection, the operator must:
  - a. Remove all drilling equipment, including the derrick, from the premises within 60 days after completion of any well.
  - b. Remove all auxiliary facilities no longer needed.
  - c. Remove from the site all concrete, pipe, wood, or other foreign materials to a depth of 4 feet below grade except those facilities directly needed to operate the well.

d. Fill and pack all holes and depressions with native earth.

f. All sumps and/or ponds must be purged of environmentally harmful chemicals, filled and packed with native earth and replanted to county landscaping standards.

7. Noise - The maximum permitted sound level for both air and mud drilling shall be 65 decibels at a distance of one-half mile from the drill site using the "A" scale and measured as set out on Page 1, paragraph 7.

8. When air drilling, dust shall be controlled by whatever means necessary and shall not exceed the standards as set in Section 6.8 and 6.9 of Ordinance No. 645.

B. Restricted Areas - Drilling standards (These are in addition to the county-wide standards and the County Planning Commission shall determine if a site is a restricted area.

1. All work, in preparation of the site for drilling, including rocking of pipe, storage and equipment removed shall be done between the hours of 7 a.m. and 7 p.m.

2. All unattended well sites shall be enclosed by a steel chain link-type fence six (6) feet high. There shall be no opening, below such fence, greater than four (4) inches. The gate shall be placed at a nonhazardous-location and shall be locked at all times.

3. All lights shall be directed or shielded as to conform with Section 6.10 of the Lake County zoning ordinances.

4. The delivery or removal of equipment or material shall be limited to the hours from 7 a.m. to 7 p.m., except in the case of emergencies.

5. No unusual or unnecessary noise will be allowed between the hours of 7 p.m. and 7 a.m.

6. The drilling site and access roads shall be treated to eliminate dust and mud as prescribed by the County Road Department.

7. Sound - The maximum permitted sound level for drilling shall be 50 decibels at a distance of 500 feet using the "A" scale and measured with a Sound meter and associated octave band analyzer, conforming to standards prescribed by the United States of America Standards Institute Criteria relating to noise and sound measurements.

## II. PRODUCING STANDARDS

### A. County-Wide Producing Standards

1. All permanent construction work will require a building permit. The fees and procedures will be based on the Uniform Building Code as amended and adopted by the Lake County Board of Supervisors.
2. Continuous and intermittent sound shall be controlled to the levels acceptable in the Restricted Area - Drilling Standards.
3. Power lines shall be constructed on existing power line right-of-ways wherever possible. Any new power line installations shall conform with county optimum land use and aesthetic requirements.
4. All power plants, cooling towers, and accessories such as pipelines and switchyards shall be designed, constructed, and screened as much as possible to blend with the natural surroundings. Such exterior design and aesthetics, including landscaping shall be approved by the County Planning Commission.
5. All permanent access roads shall be constructed to be as inconspicuous as possible. Such roads to be constructed to eliminate dust to the satisfaction of the County Road Commissioner. All cuts and fills shall be planted to prevent erosion.
6. All permanent power plant sites shall be planted and maintained with trees, shrubs, and grass that will: (1) Be compatible with indigenous species and (2) compliment the appearance of the installation in its natural environment. (3) follow plans approved by the Lake County Planning Commission.

### B. Restricted Areas - Producing Standards

1. All applicable requirements imposed by the County-Wide Producing Standards shall remain in effect.
2. All pipelines shall be screened as approved by the Planning Commission.
3. All well heads and related pipelines shall be constructed and/or landscaped to blend with the natural environment.

### III. PLANNING STANDARDS - County-Wide

1. All Geothermal Drilling sites including test facilities and ponds shall be developed as compactly as possible and in no case spread over an area larger than 5 acres on arable land. Exceptions will be allowed if two or more wells are drilled from the same site, provided however, that any proposed well or wells shall be located on a single parcel or accumulation of parcels of not less than 20 acres, unless specifically waived by the County Planning Commission.
2. All roads shall be constructed in such a manner as to not upset the natural aesthetics of the landscape. All roads shall follow the natural contours of the land as much as possible. (All cuts or fills will be held to a minimum, and exterior banks shall be planted).
3. Unless specifically waived by the Planning Commission where legally permissible, the following minimum distances shall be observed in siting a well:
  1. Outer Boundary of Parcel 100 feet
  2. Public Roads 100 feet
  3. Residence 500 feet
  4. School 2640 feet
  5. Hospital 5280 feet
  6. Any other development 500 feet
4. Production facilities shall where possible, be located in centralized areas to serve the maximum number of wells. These shall include but are not limited to power plants, extraction plants, and separators.
5. All electrical transmission lines shall be constructed on existing right-of-ways wherever possible, and where practical electric distribution lines shall be placed underground if well is producing.
6. The plans for all permanent sumps or ponds shall be designed and constructed under the supervision of a registered Civil Engineer and to the approval of the Lake County Health Department.

The following are considered minimum criteria:

1. Pond bottoms and dykes shall be either impervious or shall be lined to prevent seepage.
2. Earthen dykes shall have 3:1 slopes and the outside shall be planted.

3. Dykes shall be designed to provide 3 feet free board when at design capacity.

4. Protect from any flood hazard.

The plans shall be submitted for County Planning Commission approval.

7. A reproducible copy of the plot plan shall be submitted on suitable material. It shall be not less than 18" x 26" with an appropriate scale and shall be prepared in accordance with good engineering and drafting techniques. It shall show all existing topography and facilities and shall clearly proposed geothermal development, including landscaping plans.

8. Fire clearance of brush shall be as required by the State Division of Forestry P.R.C. Div. 4, Part 2, Chap. 3, Sections 4291, 4292, and 4293.

9. The removal of ground cover in areas not immediately needed for normal operations shall be done only with the approval of the Planning Commission.

10. Pollutants exhausted to the air, including dust and noxious gases, shall not exceed the standards set out in Sections 6.7, 6.8, and 6.9 of the Lake County Zonning Ordinance No. 645.

GEOTHERMAL POWER

OPEN SYSTEM

6.7 Smoke: No emission shall be permitted at any point from any chimney or otherwise of visible gray smoke or of a shade equal to or darker than no. 2 on Power's Micro Ringlemann Chart published by the McGraw-Hill Publishing Co., Inc. and copyright 1954 (being a direct facsimile reduction of a standard Ringlemann Chart as issued by the United States Bureau of Mines) except that visible gray smoke of a shade equal to No. 3 on said chart may be emitted for four (4) minutes in any thirty (30) minutes, not including agricultural uses.

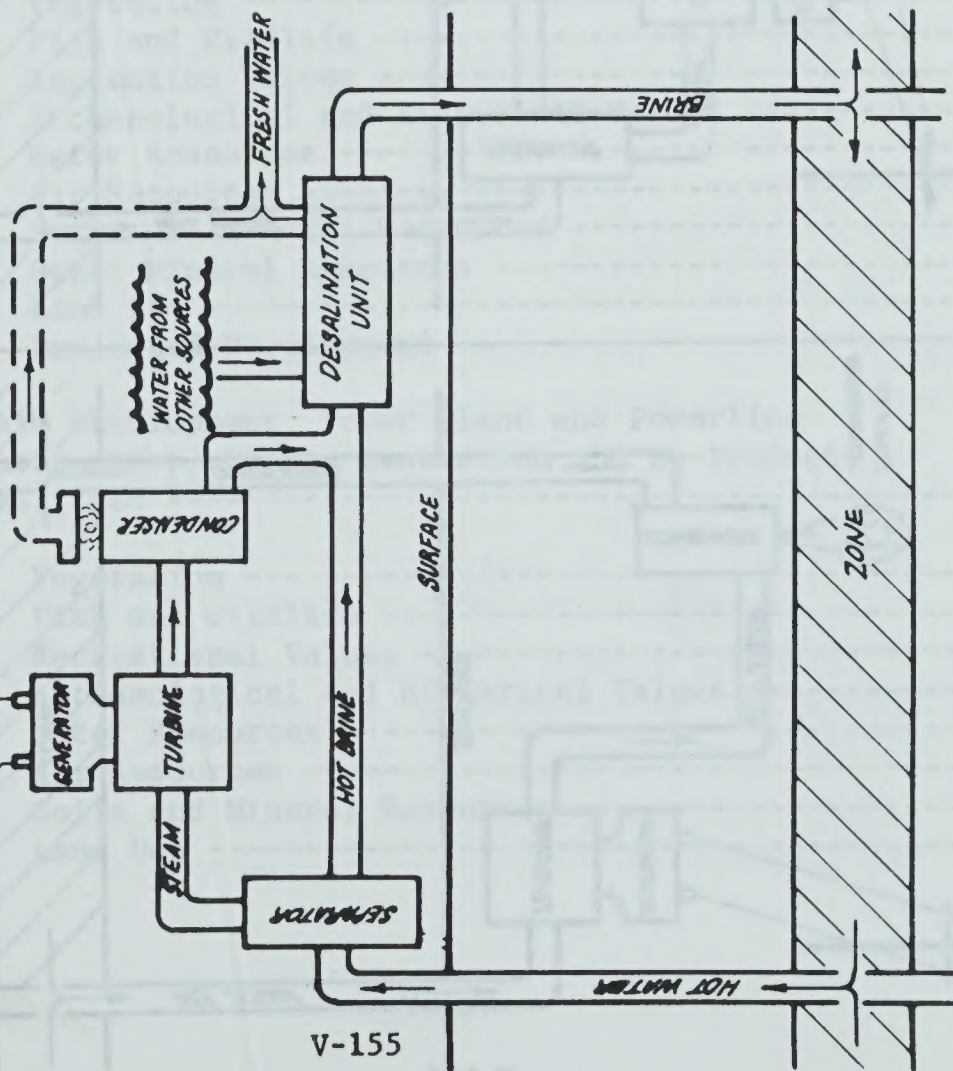
6.8 FLY ASH, DUST, FUMES, AND OTHER FORMS OF AIR POLLUTION: No emissions of pollutants shall be permitted which result in concentrations measured at the lot line in excess of those specified in the Ambient Air Quality Standards of the State of California Air Resources Board.

6.9 Odors, gases and other forms of emission: No emissions of odorous gases or other odorous substances, other than those specified by the aforementioned Ambient Air Quality Standards, shall be permitted which result in concentrations measured at the lot line which are readily detectable when diluted in the ratio of one volume of odorous air to four volumes of clean air. As a guide in determining the quantities of offensive odors, Table III, "Odor Thresholds", in Chapter 5, "Air Pollution Abatement Manual", copyright 1951 by the Manufacturing Chemists' Association, Inc., Washington, D. C. shall be used.

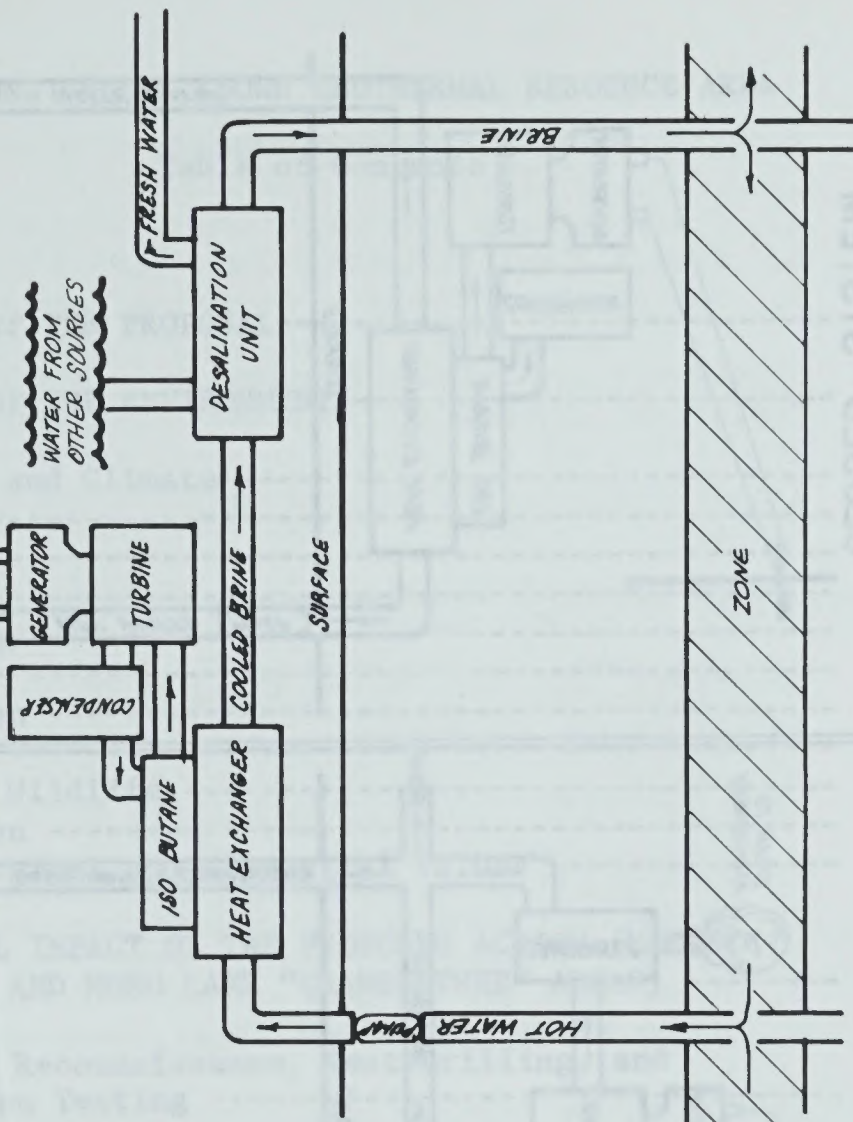
6.10 Glare: No direct or reflected glare, whether produced by floodlight, high temperature processes such as combustion or welding, or other processes, so as to be visible from any boundary line of property on which the same is produced shall be permitted. Sky-reflected glare from buildings or portions thereof shall be so controlled by such reasonable means as are practical.

# GEOHERMAL POWER AND DESALINATION PLANTS

OPEN SYSTEM

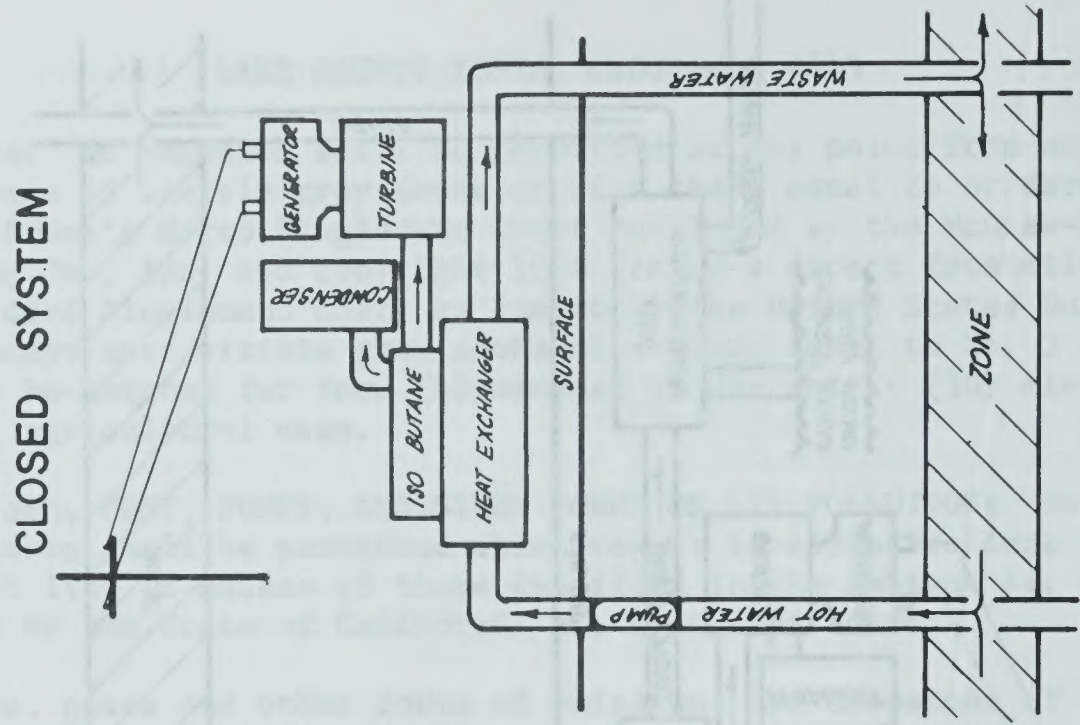
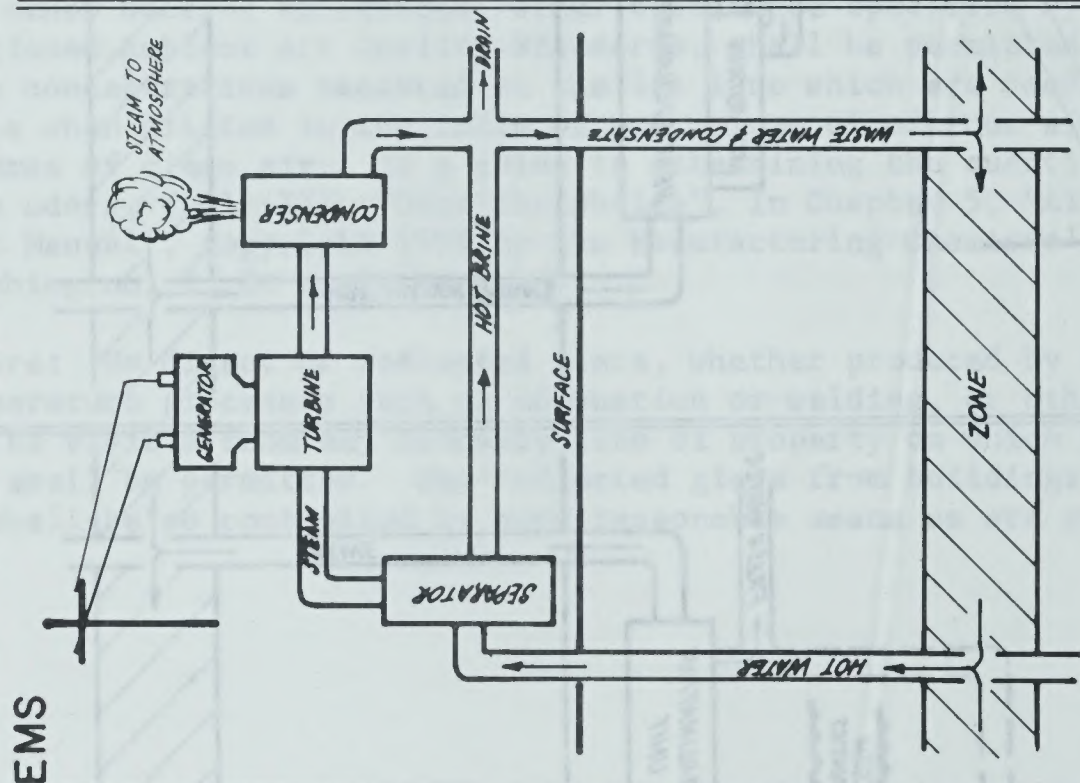
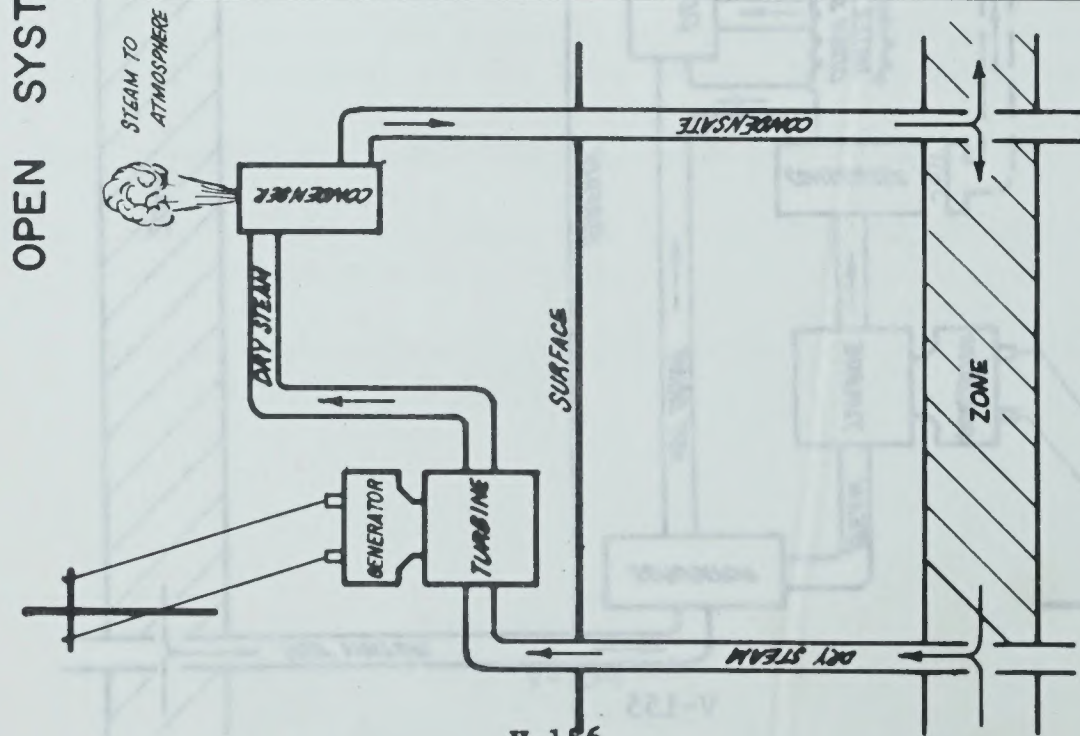


CLOSED SYSTEM



# GEOTHERMAL POWER PLANTS

## OPEN SYSTEMS



# MONO-LONG VALLEY KNOWN GEOTHERMAL RESOURCE AREA

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A. DESCRIPTION OF THE PROPOSAL

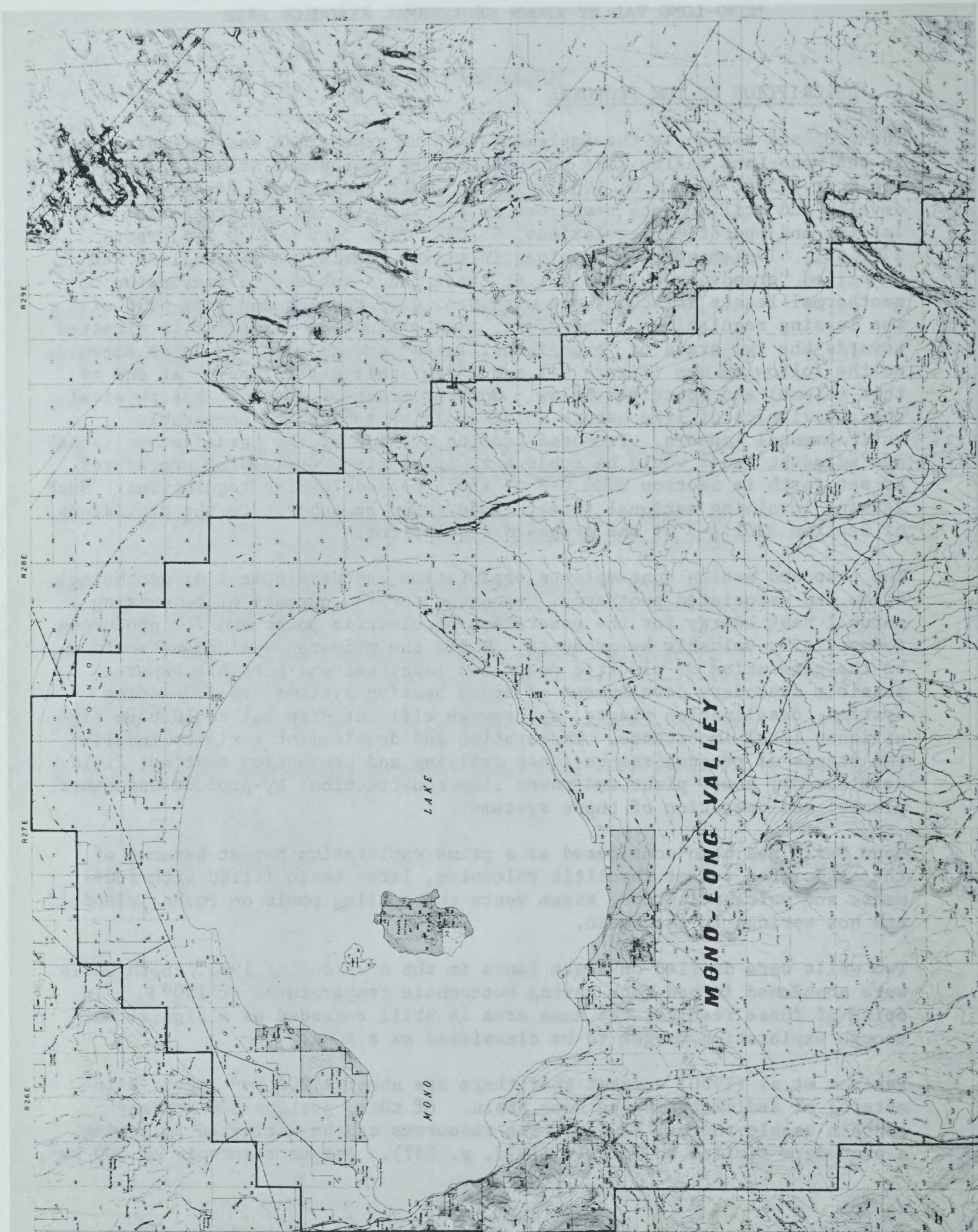
The proposed action is the implementation of geothermal resources leasing in the Mono-Long Valley KGRA pursuant to the Geothermal Steam Act of 1970 (84 Stat. 1566; 30 U.S.C. 1001-1025) so as to perfect the rights to develop and utilize such resources in accordance with the geothermal leasing and operating regulations, 43 CFR, Part 3200 and 30 CFR, Parts 270, 271. Implementation involves initially leasing most or all of the so-called "grandfather lands," i.e., those lands subject to conversion to geothermal leases in accordance with Sec. 4 of the Act and Part 3230 of the leasing regulations. Therefore, this evaluation primarily is directed towards the two areas of "grandfather lands" and adjacent lands as shown on the following map (Figure M-1 and large-scale map in pocket at end of this volume) and described below. However, much of the area has physical characteristics of like nature which could be subject to comparable environmental impacts. Proposed leasing outside of the "grandfather lands" and adjacent lands would be subject to appropriate preleasing procedures as set forth in Section 3200.0-6 of the proposed leasing regulations. Such leasing involving national forest lands would be subject to the provisions of Section 3201.1-3 of the proposed regulations.

The proposed action contemplates exploration and development of geothermal steam and associated geothermal resources for the purpose of harnessing natural heat energy for the generation of electric power and for producing commercially valuable by-products. While the primary development would be the generation of electric power for local use and possible export, possible secondary development of space heating systems, road de-icing systems, desalination plants, and sewage effluent disposal could have significant local importance. Exploration and development activity involves the stages of reconnaissance; test drilling and production testing; field development; power plant and power line construction; by-product and other plants; and operation of those systems.

Mono Basin has been considered as a prime exploration target because of the associated recent rhyolitic volcanism, large basin filled with sediments and volcanoclastics, steam vents and boiling pools on Poaha Island, and hot springs in the basin.

Two wells were drilled on State lands in the area during 1971. Both wells were abandoned in bed rock having bottomhole temperatures of 150° F. In spite of these results, the Mono area is still regarded as a significant enough exploration target to be classified as a KGRA.

Pakiser et al (1960) suggest that there are about 1,200 km<sup>3</sup> (cubic.kilometers) of sediments in the Mono Basin. Of this, perhaps 300 km<sup>3</sup> may contain usable thermal fluids. The resources can be estimated following a procedure similar to Muffler (1973, p. 257). Assume reservoir of 300 km<sup>3</sup>,



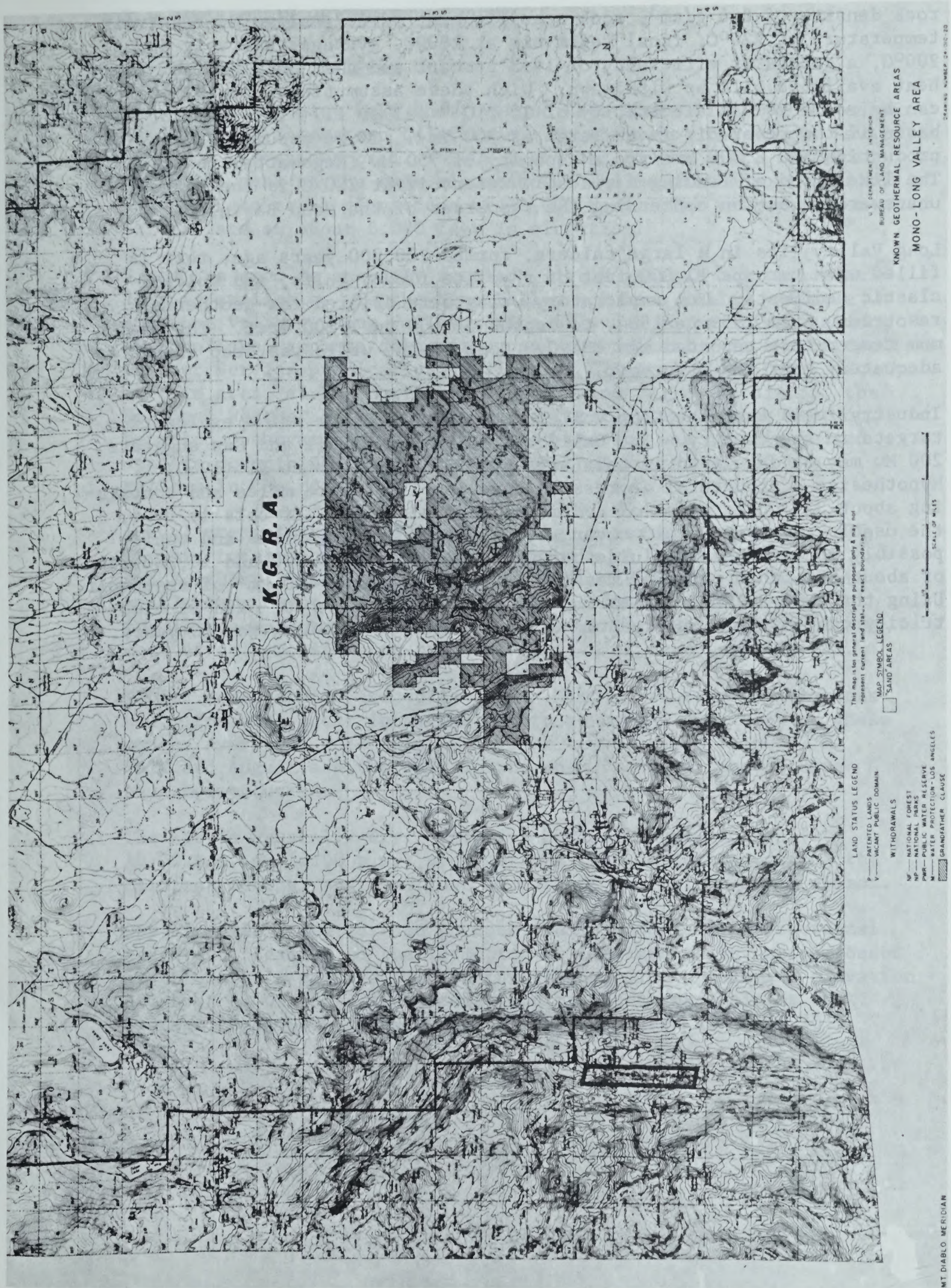


Figure M-1

rock density of  $2.6 \text{ g/cm}^3$ , rock specific heat of  $0.2 \text{ cal/gm}^\circ\text{C}$ , reservoir temperature of  $220^\circ\text{C}$ , final reservoir at  $180^\circ\text{C}$ , average reservoir at  $200^\circ\text{C}$ , a generator efficiency of 14.3 percent and that only half of the heat available will be withdrawn. With these assumptions,  $5 \times 10^{14} \text{ cal/km}^3$  can be recovered as electricity of  $15 \times 10^{16} \text{ cal}$  or  $1.7 \times 10^{11} \text{ kwh}$  for the basin if the reservoir is as large as  $300 \text{ km}^3$ . If we assume 30 years of production and 8,000 hrs/yr, a capacity of 750 Mw (Megawatts) is possible. The likelihood of finding a sizeable reservoir at  $220^\circ\text{C}$  is the largest unanswered question concerning the resources of the Mono Basin.

Long Valley lies in a large caldera, formed 700,000 years ago, that is filled with perhaps 12,000 feet of rhyolite flows, tuffs, and volcaniclastic sediments. Ten exploratory wells were drilled for geothermal resources, from 1959 to 1964, to depths of 400 to 1,200 feet. The maximum temperature reported was  $181^\circ\text{C}$ . None of the wells was deep enough to adequately test the reservoir.

Industry feels that the Long Valley area is one of the prime exploration targets in the country. The California Division of Oil and Gas suggests 200 Mw may be developed in this area by 1985. Pakiser et al (1960) hypothesize a structural depression covering 150 square miles and containing about 375 cubic miles of sediments and volcanics. If this is true, the usable reservoir could cover as much as 100 square miles and would possibly contain usable fluids between the depths of 5,000 and 10,280 feet or about 100 cubic miles of reservoir. This is about  $420 \text{ km}^3$  of reservoir. Using the same assumptions as for the Mono Basin,  $2.4 \times 10^{11} \text{ kwh}$  of electricity can possibly be produced at a capacity of 1,000 Mw for 30 years.

## B. DESCRIPTION OF THE ENVIRONMENT

### 1. Location and Climate

The Mammoth-Crowley Lake and the Mono Lake areas lie in a series of arid valleys in eastern California. To the west, the Sierra Nevada rises to elevations of 12-14,000 feet, and to the east, the White Mountains peak at the same elevations. The mountains northeast of Crowley Lake reach elevations of 11,000 feet. The valleys, themselves, are at about 6,000 feet in elevation.

Since the area is sparsely settled, little general climatological data is available. In the Mono Valley - Pumice Valley - Little Antelope Valley - Long Valley region only one cooperative station, at Mono Lake, reports temperature and precipitation in the National Weather Service publication, California Climatological Data. South of this area, at the north end of the Owens Valley in Bishop, the National Weather Service maintains a first-order weather station. Detailed observational data from that station was heavily relied upon in describing the meteorological characteristics of the valleys in the north.

Annual precipitation averages less than 6 inches, and about half of this total occurs in the winter months of December, January, and February. Snowfall, concentrated in the months of December and January, averages nearly 7 inches per year. Winter storms are infrequent and those that continue on into Nevada precipitate most of this moisture on the western side of the Sierra Nevada.

Winter temperatures are quite cold. Minimum average temperatures below freezing occur in November through March, with each of these months averaging more than 20 days of temperatures below 32°F. July and August are the only months when freezing temperatures have not occurred.

The air is unusually dry. Relative humidity measurements (at 10:00 a.m. and 4:00 p.m.) average less than 50 percent during the rainiest months, and less than 20 percent during the drier season.

Dry air over a dry surface produce ideal conditions for nocturnal radiation, leading to the formation of temperature inversions based at the earth's surface. These inversions, plus the area's elevation of about 6,000 feet, undoubtedly contribute to maintaining the average, December - January minimum temperatures at about 20°F.

The terrain configuration indicates that mountain and valley wind conditions prevail. The narrative climatological summary for Bishop indicates an early morning and late evening northerly wind in summer and autumn, switching to southerly during the afternoon. The strongest winds are observed in spring and they come from the north. A dominant, cold, high pressure area, centered over the Great Basin, during the winter season, generates stagnant meteorological conditions westward to the Sierra Nevada.

The following map (Figure M-2) depicts average snow depth, average annual precipitation, and strong wind areas in the Mammoth-Crowley Lake area.

a. Mammoth-Crowley Lake Area

The Mammoth-Crowley Lake "grandfather" area encompasses approximately 30 square miles in Mono County, California. The area is in east-central California, about 35 miles north of Bishop and approximately 200 miles south of Reno, Nevada. The town of Mammoth is located on State Route 203, approximately 5 miles west of the Mammoth-Crowley Lake "grandfather" area and Highway 395.

Just east of the Mammoth-Crowley Lake "grandfather" area lies Lake Crowley, a man-made lake with a capacity of 183,465 acre-feet, which forms part of the water system of the City of Los Angeles.

b. Mono Lake Area

The Mono Lake "grandfather" area encompasses approximately 6 square miles, principally in Mono County, California. The area is in east-central California, about 60 miles north of Bishop and approximately 160 miles south of Reno, Nevada. Lee Vining, with a population of 400, is the only town in the area, and is located on the western edge of Mono Lake near the junction of U.S. Highway 395 and State Highway 120.

Mono Lake, a natural lake of 84 square miles, is in a closed basin with no outlet. Waters are highly mineralized and do not support fish life. Almost all of the former tributary flow to Mono Lake is diverted into the Los Angeles aqueduct system via Owens Valley.



## 2. Water

### a. Mammoth-Crowley Lake Area

The Mammoth-Crowley Lake "grandfather" area occupies portions of two drainage basins, the Owens River watershed and the Mammoth Creek watershed. The following map (Figure M-3) shows the location of the Owens River watershed and the Mammoth Creek watershed relative to the Mammoth-Crowley Lake KGRA areas and the water resource. Surface water is the most important source of local agricultural and of local and exported domestic water supplies. Although much of the water yield in the "grandfather" area is used in one manner or another, there is relatively little specific data on water quantity. From existing data, the flow characteristics of 15 gauging stations have been summarized. These summaries are presented in Table M-1.

Even fewer data are available concerning water quality. Due to the scarcity and lack of consistency of available water quality data, no attempt has been made to summarize this data, for the entire area. The limited data on water quality is summarized in Table M-2. Generally, the surface water quality of the "grandfather" area is good to excellent for both existing and potential uses. Most of the surface waters are of moderately soft bicarbonate type, with low dissolved mineral content and are nearly neutral in pH. Exceptions to these general conditions are areas such as portions of Hot Creek and Mammoth Creek, which are influenced by local hot springs, resulting in higher mineral content and increased temperatures.

In the Mammoth-Crowley Lake "grandfather" area, the national resource lands are withdrawn for the City of Los Angeles for watershed protection purposes. There are approximately 68 square miles of City of Los Angeles owned land in Long Valley which produces about 30 percent of the water transported through the Los Angeles aqueduct.

In Crowley Lake, outflow of surface water exceeds inflow, and subsurface drainage is vital to maintenance of the lake. Thus, the Department of Water Power, City of Los Angeles, is concerned over possible contamination from subsurface causing leaks. Possible siltation and sedimentation of Crowley Lake are of further concern to the Department.

### b. Mono Lake Area

Mono Lake lies in a closed drainage basin and is experiencing rapid desiccation due to diversion of most of the tributary stream runoff. Water which would normally enter Mono Lake has been diverted to Lake Crowley via the Mono Craters aqueduct.

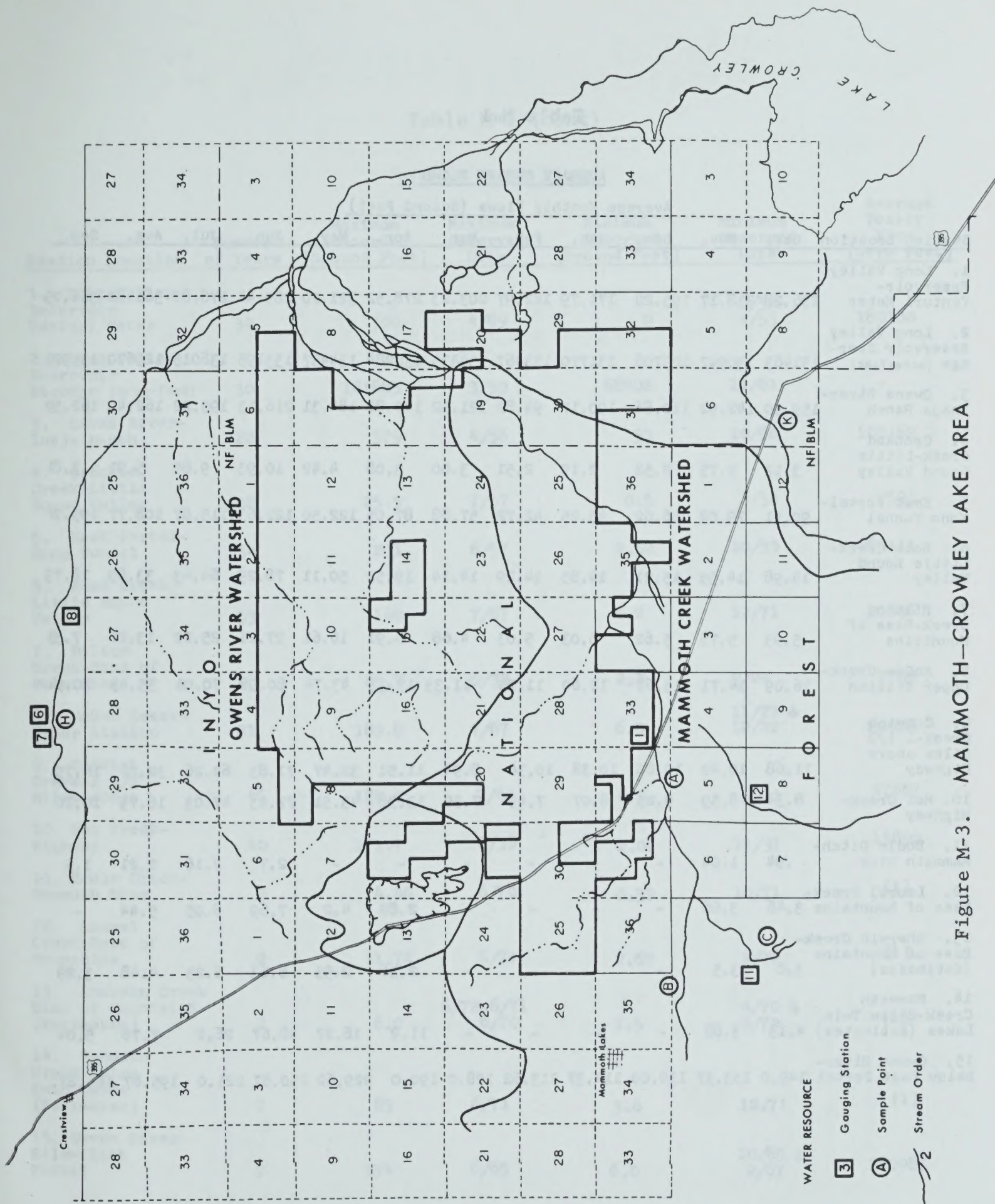


Figure M-3. MAMMOTH-CROWLEY LAKE AREA

Table M-1

AVERAGE STREAM FLOWSAverage Monthly Flows (Second Feet)

Station Location	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1. Long Valley Reservoir-Venturi Meter	236.28	238.17	195.22	171.79	182.97	203.23	278.52	321.20	289.44	278.82	361.82	316.25
2. Long Valley Reservoir Storage (acre-feet)	131463	130947	125706	131770	133467	134435	136284	134457	133195	138015	129620	135929
3. Owens River-Inaja Ranch	159.90	142.90	110.86	100.17	94.82	121.52	140.81	184.31	216.13	195.22	162.40	162.59
4. Crooked Creek-Little Round Valley	3.12	2.75	2.52	2.19	2.51	3.00	3.08	4.42	10.93	9.85	5.91	3.81
5. East Portal-Mono Tunnel	90.91	79.02	56.62	45.25	42.72	57.88	87.05	122.50	122.63	115.87	108.77	105.72
6. Rock Creek-Little Round Valley	14.98	14.55	15.21	14.85	14.29	14.14	19.52	50.11	78.29	64.43	33.89	18.79
7. Hilton Creek-Base of Mountains	5.93	5.75	5.62	5.03	5.03	4.68	6.91	16.61	27.21	25.22	13.26	7.33
8. McGee Creek-Upper Station	16.09	14.71	13.62	12.60	11.75	11.35	17.33	43.74	80.98	70.01	35.45	20.54
9. Convict Creek-1 1/2 Miles above Highway	11.68	10.49	10.80	10.38	10.34	8.94	11.51	32.47	71.83	64.26	32.22	16.79
10. Hot Creek-Highway	8.34	8.59	9.25	8.07	7.49	7.36	13.38	43.51	77.23	47.03	18.79	10.10
11. Bodle Ditch-Mammoth Mine	.94	1.04	-	-	-	-	-	-	2.7	2.16	2.21	1.5
12. Laurel Creek-Base of Mountains	3.46	3.66	-	-	-	-	2.82	4.2	7.69	8.05	5.44	-
13. Sherwin Creek-Base of Mountains (Estimates)	3.0	3.5	-	-	-	-	2.38	2.95	6.63	6.25	4.48	3.29
14. Mammoth Creek-Below Twin Lakes (Estimates)	4.13	3.88	-	-	-	-	11.2	18.27	48.67	26.2	7.76	5.04
15. Owens River-Below East Portal	149.0	153.37	130.00	114.37	113.62	128.0	190.0	229.62	250.87	221.0	195.87	164.87

Table M-1 (cont)

Average Stream Flows

Station Location	Number of Years	Maximum Observed (Second Feet)	Maximum Observed Date	Minimum Observed (Second Feet)	Minimum Observed Date	Average Yearly Flow (Acre Feet)
1. Long Valley Reservoir- Venturi Meter	34	700	4/69	0	6/52- 4/53	189180
2. Long Valley Reservoir Storage (acre-feet)	30	181885	3/59	68402	11/61	-
3. Owens River- Inaja Ranch	22	379	4/56	53	10/60	108162
4. Crooked Creek-Little Round Valley	52	25.5	7/57	0.5	4/34	2593
5. East Portal- Mono Tunnel	34	251	6/57	2.52	10/39	65111
6. Rock Creek- Little Round Valley	53	149	7/67	6.2	12/71	21696
7. Hilton Creek-Base of Mountains	48	85.7	6/38	2.3	9/24	7783
8. McGee Creek- Upper Station	51	189.8	7/67	6.0	11/22 & 12/22	20928
9. Convict Creek-1 1/2 Miles Above	46	180.0	7/67	4.2	3/31	17667
10. Hot Creek- Highway	40	171.7	6/38	2.06	11/31	15690
11. Bodle Ditch- Mammoth Mine	2	4.46	6/70	0.32	10/71	(1)
12. Laurel Creek-Base of Mountains	2	11.74	6/71	2.67	4/72	(1)
13. Sherwin Creek Base of Mountains (Estimates)	2	8.0	6/72, 6/71 6/70	1.5	4/70 & 5/70	(1)
14. Mammoth Creek-Below Twin Lakes (Estimates)	2	85	6/71	3.0	12/71	(1)
15. Owens River- Below East Portal	9	334	6/65	6.0	10/65 & 2/67	120987

(1) Insufficient Data Available

Table M-2. Water analysis from various sources in Long Valley, California

	Hot Spring on Little Hot Creek NW1/4 Sec. 13, T. 2S, R. 29E.	Hot Spring, NE1/4 Sec. 31, T. 2S, R. 29E.	Big Spring (Local Meteroic Water) NW1/4 Sec. 25, T. 2S, R. 29E.	Steam Condensate and Fluid - Magma Ritchie #5, NW1/4 Sec. 32, T. 2S, R. 28E.	Hot Spring, S cent. 1/4 Sec. 21, T. 3S, R. 29E.
	ppm	ppm	ppm	ppm	ppm
SiO <sub>2</sub>	91	120	58	170	200
Al	0.006	0.006	0.002	---	0.002
Be	0.000	---	---	0.000	---
Hg	<0.0001	0.0001	<0.0001	0.001	<0.0001
As	0.74	0.84	0.02	2.2	0.46
Ca	50	15	5.1	0.9	25
Mg	0.6	0.4	5.9	0.1	0.6
Sr	0.60	0.28	0.07	0.14	0.20
Ba	0.000	0.000	0.000	0.000	0.020
Na	410	310	2.3	390	310
K	30	22	4.0	45	37
NH <sub>4</sub>	0.4	0.09	0.13	0.4	0.2
HCO <sub>3</sub>	735	515.6	90.4	449.9	828.3
CO <sub>3</sub>	0.29	1.9	0.02	29.6	0.3
SO <sub>4</sub>	96	81	8.1	130	68
Cl	200	170	5.7	280	150
F	8.5	7.5	0.51	12	4.6
Br	0.8	0.6	0.2	1.1	0.5
I	0.8	0.5	0.000	0.4	0.4
NO <sub>2</sub>	<0.05	<0.05	<0.05	<0.05	<0.05
NO <sub>3</sub>	0.05	0.05	0.1	<0.05	0.05
PO <sub>4</sub>	0.15	0.43	1.0	0.18	0.28
B	10.6	---	---	15	7.7
Se	0.005	0.000	0.000	0.001	0.005
Temp. (°C)	79	58	11	2	56
Dissolved solids residue - 180°C (ppm)	1260	1000	156	1420	1260
Specific conductance (Micromhos at 25°C)	1950	1500	182	1920	1790
pH	6.51	7.53	6.83	9.25	6.53
Sulfides as H <sub>2</sub> S (ppm)	2.3	0.8	0.1	10	0.8

Table M-2 (cont)

	Hot Spring, E cent. 1/4 Sec. 28, T. 3S, R. 29E.	Artesian Well, NW1/4 Sec. 13, T. 3S, R. 29E.	Hot Spring, S cent. 1/4 Sec. 34, T. 3S, R. 29E.	Hot Springs (pool) NW1/4 Sec. 35, T. 3S, R. 28E.
SiO <sub>2</sub>	ppm 190	ppm 64	ppm 160	ppm 200
Al	0.003	0.003	0.000	0.057
Be	0.000	0.010	---	---
Hg	<0.0001	0.0001	<0.0001	0.0003
As	0.34	0.02	0.36	0.34
Ca	22	5.3	23	3.3
Mg	0.6	0.2	1.2	0.1
Sr	0.14	0.04	---	0.1
Ba	0.000	0.000	---	0.000
Na	400	38	320	380
K	43	1.3	28	25
NH <sub>4</sub>	0.1	0.35	0.15	0.15
HCO <sub>3</sub>	845.1	111.37	694.61	465.88
CO <sub>3</sub>	0.34	2.76	0.27	0.72
SO <sub>4</sub>	69	3.7	59	120
Cl	170	3.0	150	250
F	4.8	0.57	4.6	11
Br	0.6	0.03	0.5	0.8
I	0.4	0.4	0.00	0.5
NO <sub>2</sub>	<0.05	<0.05	<0.05	<0.05
NO <sub>3</sub>	0.05	0.05	0.05	0.05
PO <sub>4</sub>	0.46	0.15	0.18	0.71
B	8.8	---	8.1	13
Se	0.004	0.002	---	0.004
Temp. (°C)	49	10	41	60
Dissolved solids residue - 180°C (ppm)	1340	166	1130	1300
Specific conductance (Micromhos at 25°C)	1900	191	1630	1800
pH	6.6	8.82	6.64	7.15
Sulfides as H <sub>2</sub> S (ppm)	0.7	3.8	0.9	1.4

Average annual precipitation in the Mono Basin, based upon meteorological station data of the Weather Service, is 12 inches. This annual precipitation contributes 32,000 acre-feet of water to Mono Lake, while ground water seepage accounts for an additional 30,000 acre-feet. Artesian springs contribute 8,700 acre-feet of underground water annually to Mono Lake. The Sierra Nevada snowpack runoff feeds 20,000 acre-feet. Evaporation of Mono Lake water has been estimated to be 174,000 acre-feet annually, (Harding , 1965). There is a net annual evaporative loss of about 80,000 acre-feet from Mono Lake. Prior to 1940, the Sierra Nevada snowpack contributed 122,000 acre-feet of water annually to Mono Lake (Mason, 1967). The completion of the Mono Craters aqueduct in 1940 diverted 103,000 acre-feet of the snowpack runoff each year from Mono Basin into the Owens Valley and Lake Crowley.

The numerous springs in Mono Basin have been categorized as basin springs, shoreline springs, and offshore springs (Lee 1969). The basin springs are of two distinct types: springs evolving through Pleistocene lake deposits, and springs discharging through fractures in andesitic volcanic rocks. Springs emanating from volcanic rocks exhibit less total dissolved solids, lower temperatures, and lower flow rates than those that flow through lake sediments.

Shoreline springs exhibit wide variations in temperature, flow rates, and composition. Along the eastern and southern parts of Mono Lake, some of the springs have warm water, high concentrations of sodium and sulfate ions, and associated hydrogen sulfide gas. In the western area, shoreline springs are generally high in sodium content. Many springs have predominantly calcium waters, which are responsible for the tufa towers in Mono Basin. The many tufa towers, with their unique forms, are the result of the precipitation of calcium carbonate.

Many springs discharge offshore in Mono Lake. Most of these have low flow rates and composition varies from fresh water to highly saline water. Tufa tower springs exist within the lake as do springs arising from sediments beneath the lake.

In general, the basin springs having bicarbonate waters are suitable for domestic consumption and general use. The warmer shoreline springs contain large amounts of sodium and boron, and are unsuitable for domestic or agricultural use. The offshore springs, being contaminated by lake water, are wholly unusable.

Concentration of salts has resulted in the lake water being twice as saline as ordinary sea water and having a pH of 9.7. The lake water also has high concentrations of phosphorous, nitrogen and carbonates. Water flow into Mono Lake consists mostly of calcium bicarbonate water, but the lake water itself is a sodium chloride - carbonate type. Wind streams crossing the lake deposit considerable amounts of salt in the surrounding area.

In 1857, the existing shoreline was surveyed and the lake elevation was established at 6,378 feet. Mono Lake rose rapidly to an elevation of

6,425 feet, reached a plateau in 1915 and remained at that level for 10 years. The lake level began its decline in 1925. This decline has accelerated since 1940 because of the diversion of runoff water to Owens Valley. In 1967, the lake level was at an elevation of approximately 6,389 feet.

### 3. Air

The California Air Quality Control Board reports that no studies have been conducted on air quality in the Mammoth-Crowley Lake or Mono Lake "grandfather" areas. Extensive study will be necessary before the existing air quality can be explicitly defined.

It is generally known that air quality in these areas is excellent owing to the lack of industrial manufacturing plants, large number of automobiles, and other man-caused activities which produce a deterioration in air quality.

### 4. Geology

The geology of the Mono-Long Valley KGRA is dominated by two large structural basins, Mono Basin and Long Valley. These basins are late Cenozoic features superimposed on a general terrain of late Paleozoic metamorphic rocks and Mesozoic granitic intrusives. Late Cenozoic volcanic rocks are abundant throughout the KGRA, with the most recent volcanic eruptions occurring as recently as 1,000 years ago (Dalrymple, 1967). The Sierra Nevada, on the west and south, and the Benton Range and the Black Mountains, on the east of the area, are composed of late Paleozoic metasedimentary rocks intruded by Mesozoic granitic rocks.

#### a. Mammoth-Crowley Lake Area

The Mammoth-Crowley Lake "grandfather" area is located in the southern part of the KGRA in the center of a large, elliptical collapse calderas. The long axis of the caldera trends East-West and extends from Mammoth Mountain ski lodge eastward for about 19 miles. Its short axis extends northward from the base of the Sierra Nevada scarp through Little Antelope Valley, the approximate center of the caldera, for a distance of about 9 miles.

The caldera was formed some 700,000 years ago by the extrusion of rhyolitic magma from a chamber at depth. As the magma was extruded, the overlying material collapsed into the ensuing void. The resulting depression was subsequently filled with clastic and volcanic material to be a probable depth of 12,000 feet. Gravity and magnetic data suggest that a mass of dense material about 3,000 feet deep now occurs near the center of the caldera and may be related to the heat source for the various thermal springs in the area.

The faults marking the boundary of the caldera show no evidence of Holocene activity, and probably have not been active since the formation of the caldera 700,000 years ago. The positions of the faults are determined in great part by gravity measurements.

The thermal springs in the area are the result of the volcanic activity which produced the caldera, and occur on or near north-to northwesterly-trending faults. The action of the hot waters escaping along the faults has resulted in hydrothermal alteration of the volcanic and sedimentary rocks in the vicinity of the springs and along the faults. The most extensive area of alteration is near the center of the caldera in the vicinity of Little Antelope Valley. Water analysis from various sources in the area were presented in Table M-2.

The mineral resources in the Mammoth-Crowley Lake "grandfather" area are limited to nonmetallic minerals. The only operating mineral deposit in the area is the Huntley Clay Pit owned by the Standard Industrial Minerals, Inc. (Photo M-1) This clay deposit was formed by hydrothermal alteration of lacustrine sandstone and rhyolite tuff breccia along a north-trending normal fault. The clay pit is on the upthrown block of the fault. The pit extends 750 feet northward along the fault and is 250 feet wide with a maximum depth of 30 feet on its east side.

Drilling in areas adjacent to the pit indicates that the clay extends to a depth of 100 feet or more. Analysis indicated that the clay is chiefly kaolinite.

A similar clay deposit occurring about a half mile northeast of Casa Diablo Hot Springs is inactive. The deposit contains china clay of excellent quality, but its development is hampered by the occurrence of stream vents and bubbling mud pools on the floor of one of the exploratory cuts on the property.

Other nonmetallic deposits occurring in the area include ornamental stone, pumice, and sand and gravel. None of these materials are being produced in the area at present, and only small amounts have been produced in the past. It is doubtful that significant future production of these materials will occur except possibly in connection with construction related to geothermal development, since adequate supplies more favorably located with respect to the market can be found outside the area.

#### b. Mono Lake Area

In contrast to Long Valley, the Mono Basin does not appear to be a caldera collapse feature and has not been the locus of voluminous volcanic eruptions during the past 4 million years (Christensen and others, 1969). The basin appears to be a downwarp, the margins of which are controlled, at least in part, by faults. There is considerable disagreement as to the importance of this faulting and as to the depth of sedimentary and volcanic fill in the Basin (Pakiser and others, 1960; Pakiser and others, 1964; Pakiser, 1965; Christensen and others, 1969; Pakiser, 1970; Christensen and Gilbert, 1970).

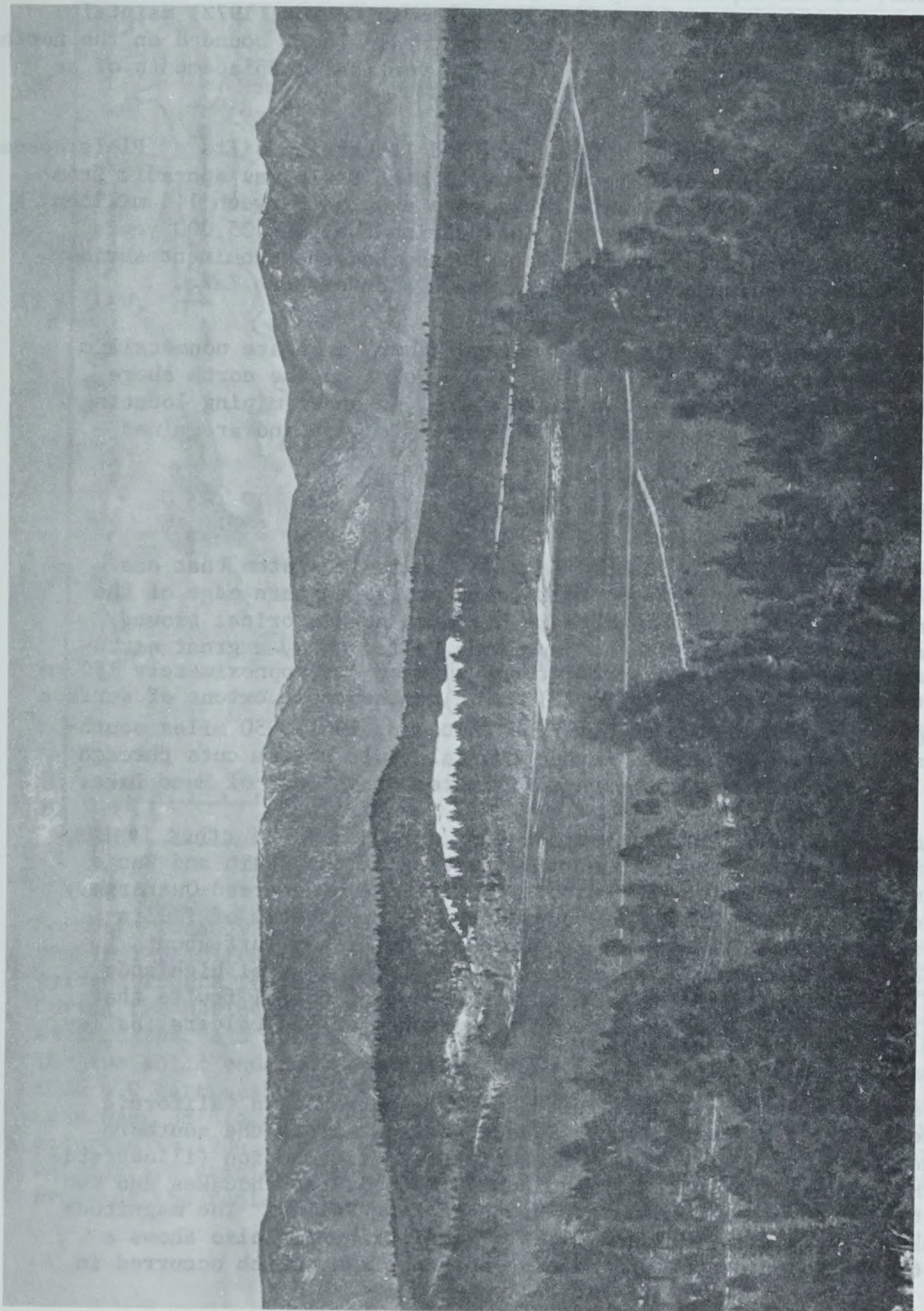


Photo M-1. Huntley Clay Pit, Standard Industrial Minerals, Inc. Located in Little Antelope Valley approximately in the center of the Mammoth-Crowley Lake "grandfather clause" area of the Mono-Long Valley KGRA. Mineral patent application filed 7/8/70 in Sec. 14 and 15, T. 3S, R. 28E, M.D.M.

Christensen and Gilbert (1970) maintain that all features of the gravity field as well as the volcanic, structural, and erosional history of the basin margins, can be explained by a layer of basin deposits on the order of 1.5 km thick. Pakiser (1970, and written communication, 1972) maintains that Mono Basin is a steeply downfaulted structural block, bounded on the north, south, and west sides by prominent faults with vertical displacements of as much as 3 km.

The basin fill consists largely of fine-grained lacustrine silts of Pleistocene age. Volcanism in and immediately adjacent to Mono Basin was sporadic from 4 to 1.5 million years. No volcanic rocks were erupted between 1.5 million years and 35,000 years. Volcanic eruptions during the past 35,000 years have formed Pahoa and Negit Islands, Black Point, and the prominent series of rhyolite domes trending south from the south side of Mono Lake.

The mineral resources of the Mono Lake "grandfather" area are nonmetallic minerals. Volcanic cinders are mined at Black Point on the north shore of Mono Lake. North Crater, on the south shore, is under mining locating for pumice. The claims are owned by U.S. Pumice Company and are mined for decorative rock.

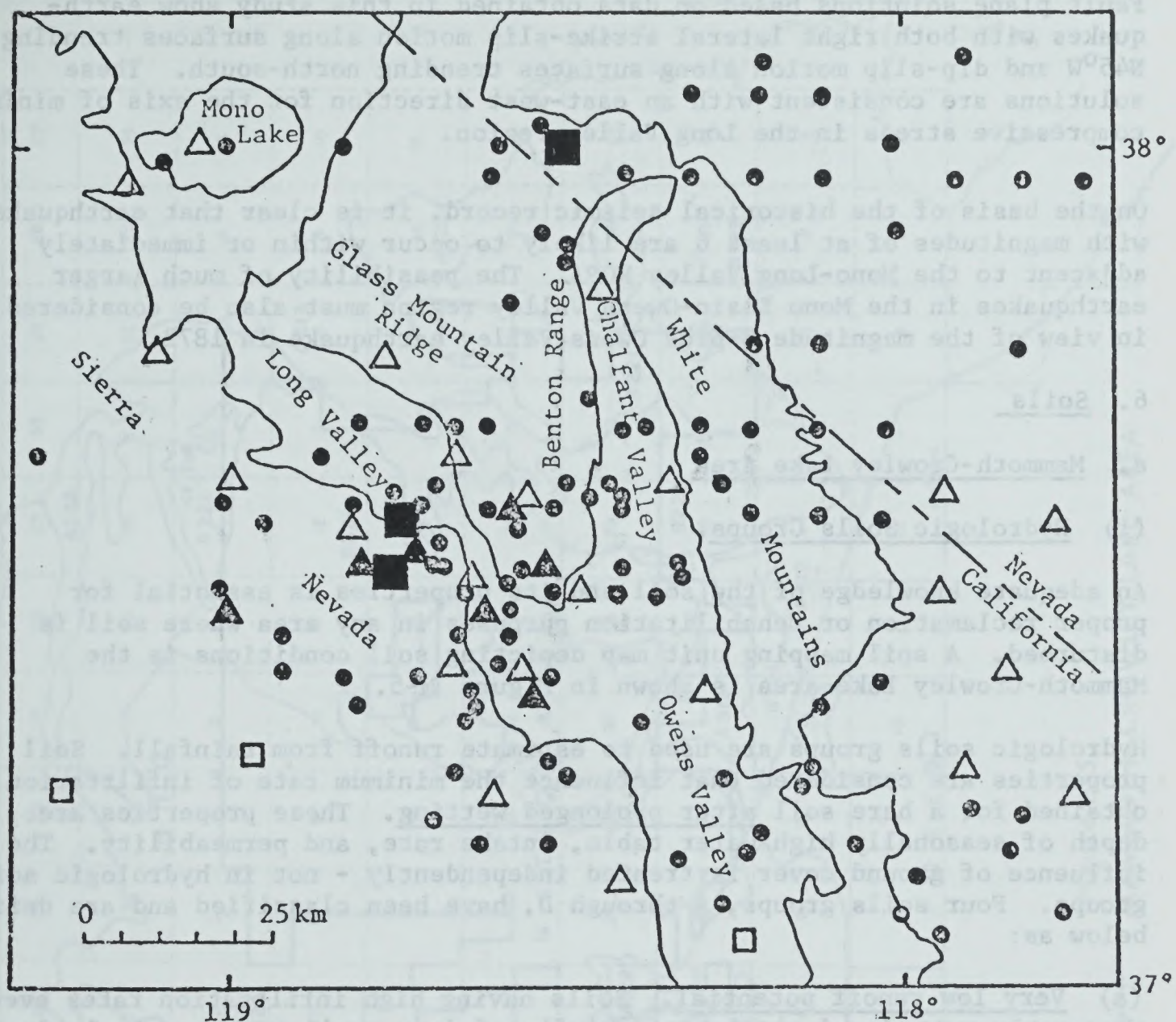
## 5. Seismology

The Mono-Long Valley KGRA is located astride the fault system that has produced the four to five thousand foot scarp at the eastern edge of the Sierra Nevada Mountains. Although there has been no historical ground displacement due to faulting in the Mono-Long Valley KGRA, a great earthquake of magnitude 8 to  $8\frac{1}{2}$  broke the ground surface for approximately 150 km on the west side of Owens Valley (1872). The northernmost extent of surface breaking appears to have been at Big Pine (Bateman, 1961), 50 miles south-east of Long Valley. The Sierra Nevada frontal fault system cuts through the center of Long Valley and passes a kilometer or so west of Mono Lake.

The Mono-Long Valley KGRA is criss-crossed by a multitude of other faults some of which are associated with normal faulting of the Basin and Range province and others of which are associated with the widespread Quaternary volcanic activity. Long Valley is bounded by a steep system of faults formed during caldera collapse and eruption of the Bishop Tuff about 700,000 years ago (Dalyrymple and others, 1965). The central highlands is Long Valley contain a system of northwest-trending normal faults that are probably associated with more recent resurgence of the caldera (Bailey, 1973).

A zone of active seismicity, which extends from southeastern California through Owens Valley to northwestern Nevada, passes across the southern half of the Mono-Long Valley KGRA. The epicenter distribution (illustrated in Figure M-4) shows a cluster of magnitude 5.0 to 5.9 earthquakes and two magnitude 6.0 earthquakes immediately south of Long Valley. The magnitude 6 earthquakes occurred in 1927 and 1941. The distribution also shows a magnitude 6.3 earthquake about 25 km east of Mono Lake, which occurred in 1934.

Figure M-4. Northern Owens Valley-Mono Lake Epicenter Distribution



Northern Owens Valley-Mono Lake region with some of the principal physiographic features outlined and labeled. Instrumental earthquake epicenters are indicated by solid symbols, all but one of which occurred during the period 1934 to 1970. Circles represent magnitude 4.0 to 4.9 earthquakes, and triangles represent magnitude 5.0 to 5.9 earthquakes. The two solid squares immediately south of Long Valley represent magnitude 6.0 earthquakes in 1941 and 1927, and the solid square east of Mono Lake near 38 degrees north latitude is a magnitude 6.3 earthquake which occurred in 1934. Open triangles and open squares represent temporary seismograph stations which were operated in 1970 during a microearthquake study of the region.

A study made by the U.S. Geological Survey in October, 1970, using 18 portable seismic stations, confirms the general earthquake distribution. Fault plane solutions based on data obtained in this study show earthquakes with both right lateral strike-slip motion along surfaces trending N45°W and dip-slip motion along surfaces trending north-south. These solutions are consistent with an east-west direction for the axis of minimum compressive stress in the Long Valley region.

On the basis of the historical seismic record, it is clear that earthquakes with magnitudes of at least 6 are likely to occur within or immediately adjacent to the Mono-Long Valley KGRA. The possibility of much larger earthquakes in the Mono Basin-Owens Valley region must also be considered in view of the magnitude 8-plus Owens Valley earthquake in 1872.

## 6. Soils

### a. Mammoth-Crowley Lake Area

#### (1) Hydrologic Soils Groups.

An adequate knowledge of the soil and its properties is essential for proper reclamation or rehabilitation purposes in any area where soil is disturbed. A soil mapping unit map depicting soil conditions in the Mammoth-Crowley Lake area is shown in Figure M-5.

Hydrologic soils groups are used to estimate runoff from rainfall. Soil properties are considered that influence the minimum rate of infiltration obtained for a bare soil after prolonged wetting. These properties are: depth of seasonally high water table, intake rate, and permeability. The influence of ground cover is treated independently - not in hydrologic soils groups. Four soils groups, A through D, have been classified and are defined below as:

(a) Very low runoff potential. Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.

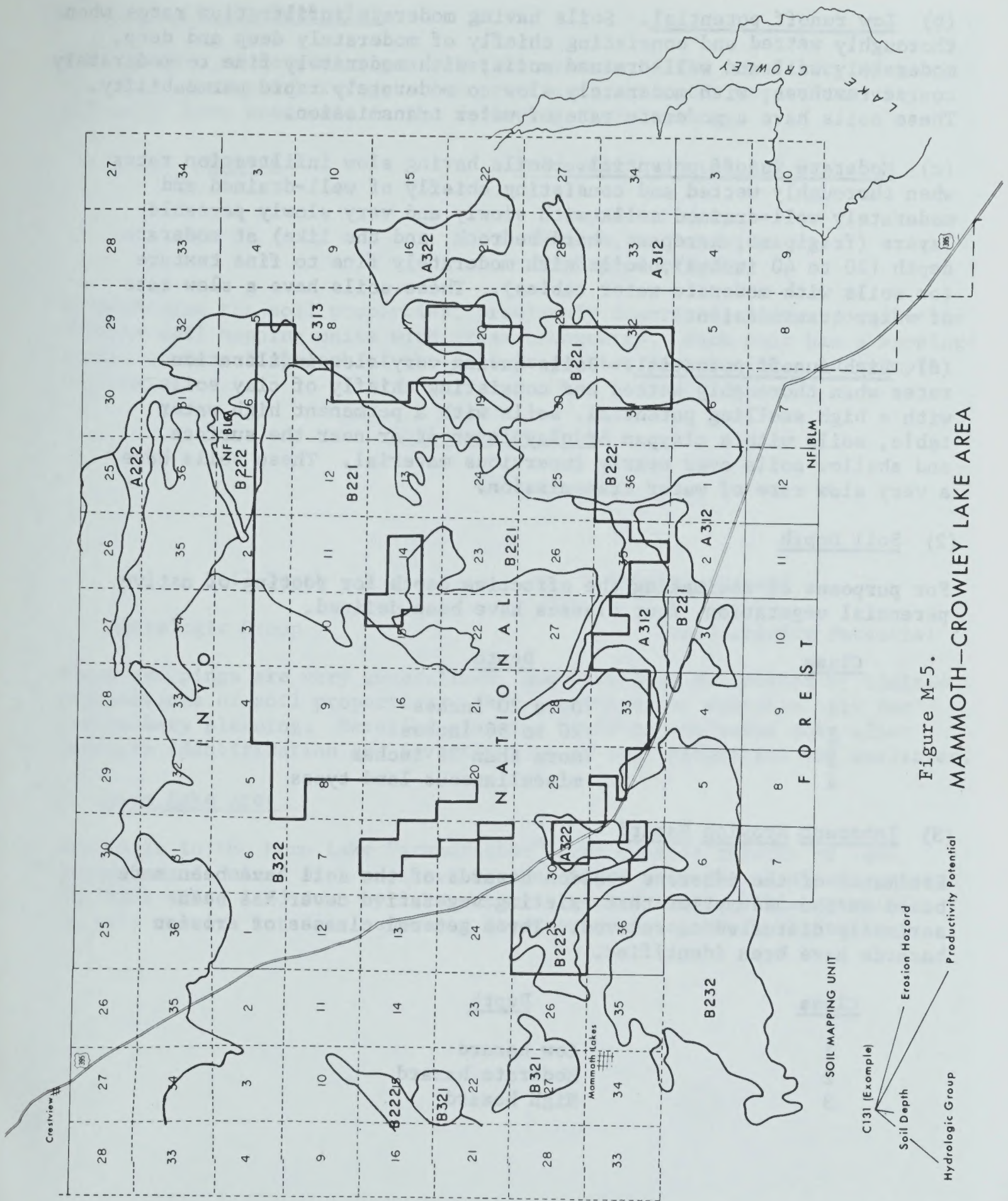


Figure M-5.  
MAMMOTH-CROWLEY LAKE AREA

(b) Low runoff potential. Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep and deep, moderately well and well-drained soils; with moderately fine to moderately coarse textures; with moderately slow to moderately rapid permeability. These soils have a moderate rate of water transmission.

(c) Moderate runoff potential. Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of well-drained and moderately well-drained soils with slowly and very slowly permeable layers (fragipans, hardpans, hard bedrock, and the like) at moderate depth (20 to 40 inches), soils with moderately fine to fine texture (or soils with moderate water tables). These soils have a slow rate of water transmission.

(d) High runoff potential. Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

## (2) Soil Depth

For purposes of estimating the effective depth for rooting of native perennial vegetation, four classes have been defined.

<u>Class</u>	<u>Depth</u>
1	0 to 20 inches
2	20 to 36 inches
3	more than 36 inches
4	miscellaneous land types

## (3) Inherent Erosion Hazard

Estimates of the inherent erosion hazards of the soil have been made based on the assumption that existing vegetative cover has been seriously disturbed or removed. Three general classes of erosion hazards have been identified.

<u>Class</u>	<u>Depth</u>
1	Low hazard
2	Moderate hazard
3	High hazard

#### (4) Productivity Potential

For purposes of determining a relative measure of the capability of a soil unit to support revegetation practices, estimates of productivity potential have been made in the following three ratings.

<u>Rating</u>	<u>Productivity Potential</u>
1	Low productivity
2	Medium productivity
3	High productivity

By combining the soil properties, previously described, it was possible to delimit soil mapping units with gross homogeneity. Each unit has a mapping symbol representing each of the soil properties inventoried. An example follows:

#### Soil Mapping Unit

C131

Soil Depth

Erosion Hazard

Hydrologic Group

Productivity Potential

These groupings are very generalized, and have been delineated by limited observations of soil properties. They are therefore suitable only for preliminary planning. Detailed planning could be conducted only after complete identification and investigation of soil properties and qualities.

#### b. Mono Lake Area

The soils in the Mono Lake "grandfather" area consist chiefly of lake deposit sands mixed with pumice. Further mixed with the sand and pumice are fine silts laid down by lake water in recent times. This material is very erosive but does support a good cover of sagebrush vegetation.

## 7. Vegetation

### a. Mammoth-Crowley Lake Area

(1) Jeffrey Pine Forest: This vegetative type encompasses the western half of the "grandfather" area (photo M-2). Crown cover densities have been divided into three classes on the timber type map. (Figure M-6) The most common density class is 10-40% crown cover. This class covers approximately 75% of the total "grandfather" area. The next density class is 40-70% crown cover which includes about 23% of the area. The 70% plus classification covers only about 2% of the area, located west of highway 395. The dominant tree species in this vegetative community is Jeffrey pine (Pinus jeffreyi). White fir (Abies concolor) is found in scattered association with Jeffrey pine near the western boundary of the "grandfather" area.

Understory vegetation is composed of shrubs, forbs, and grasses in varying density depending on tree crown density, slope, aspect, and soil depth. Principal species are big sagebrush (Artemisia tridentata), antelope bitterbrush (Purshia tridentata), rabbitbrush (Chrysothamnus spp.), snowbrush (Ceanothus velutinus), squaw currant (Ribes cereum), manzanita (Arctostaphylos manzanita), squirrel tail (Sitanion hystrix), western needlegrass (Stipa occidentalis), pussy paws (Calyptridium umbellatum), and monkey flower (Mimulus spp.).

(2) Sagebrush: The dominant vegetative community in the "grandfather" area is big sagebrush. The entire east side of the area is covered by stands of big sagebrush which occurs in varying densities, heights, and in association with other shrubs, grasses, and forbs. (Photo M-3) The most common shrubs found in this type are: antelope bitterbrush, rabbitbrush, golden bush (Haplopappus spp.) buckwheat (Friogonum spp.) desert needlegrass (Stipa speciosa), and cheatgrass (Bromus tectorum). In some areas the type grades into a sagebrush-bitterbrush association; however, these have not been delineated on the type map. In other areas big sage forms almost a pure stand.

Big sagebrush and bitterbrush are the most common understory plants present in the Jeffrey pine forest and the pinyon-juniper woodland types.

(3) Pinyon-Juniper Woodland: This vegetative community is normally present on southerly exposed ridges and slopes that are characterized by shallow, rocky soils. The dominant tree species are single-leaf pine (Pinus monophylla) and western juniper (Juniper occidentalis). Scattered Jeffrey pine also intermingle with this type on more favorable exposures where soils are deeper. Understory shrubs present in this type are: big sagebrush, bitterbrush, rabbitbrush, mormon tea (Ehpedra nevadensis), curl-leaf mahogany (Cercocarpus ledifolius), and buckwheat (Friogonum spp.).

(4) Browse or Shrub: Scattered pure stands of browse species are present in the Jeffrey pine forest and in the pinyon-juniper woodland communities. The dominant browse plant is curl-leaf mahogany. This type provides

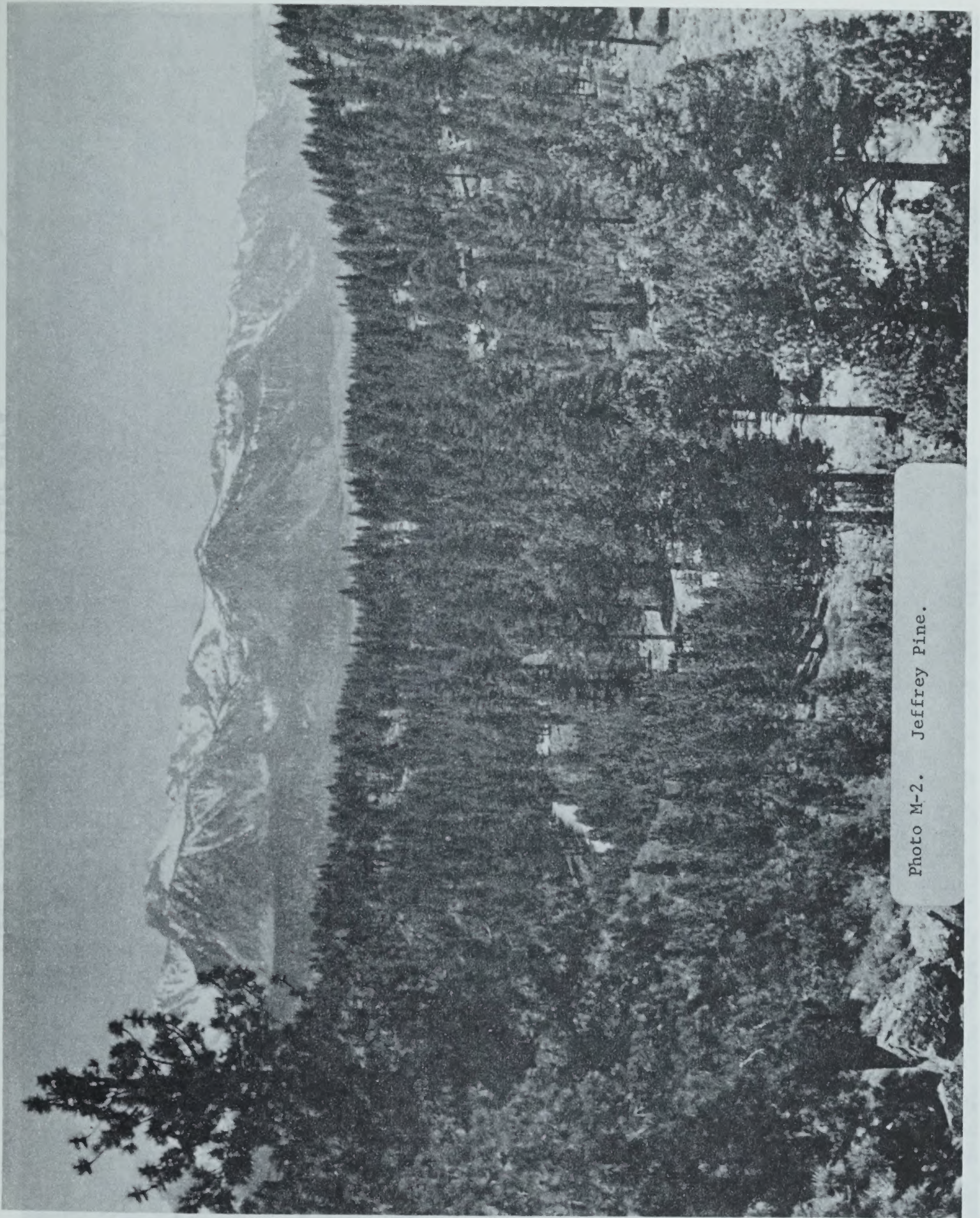


Photo M-2. Jeffrey Pine.

V-187

V-187

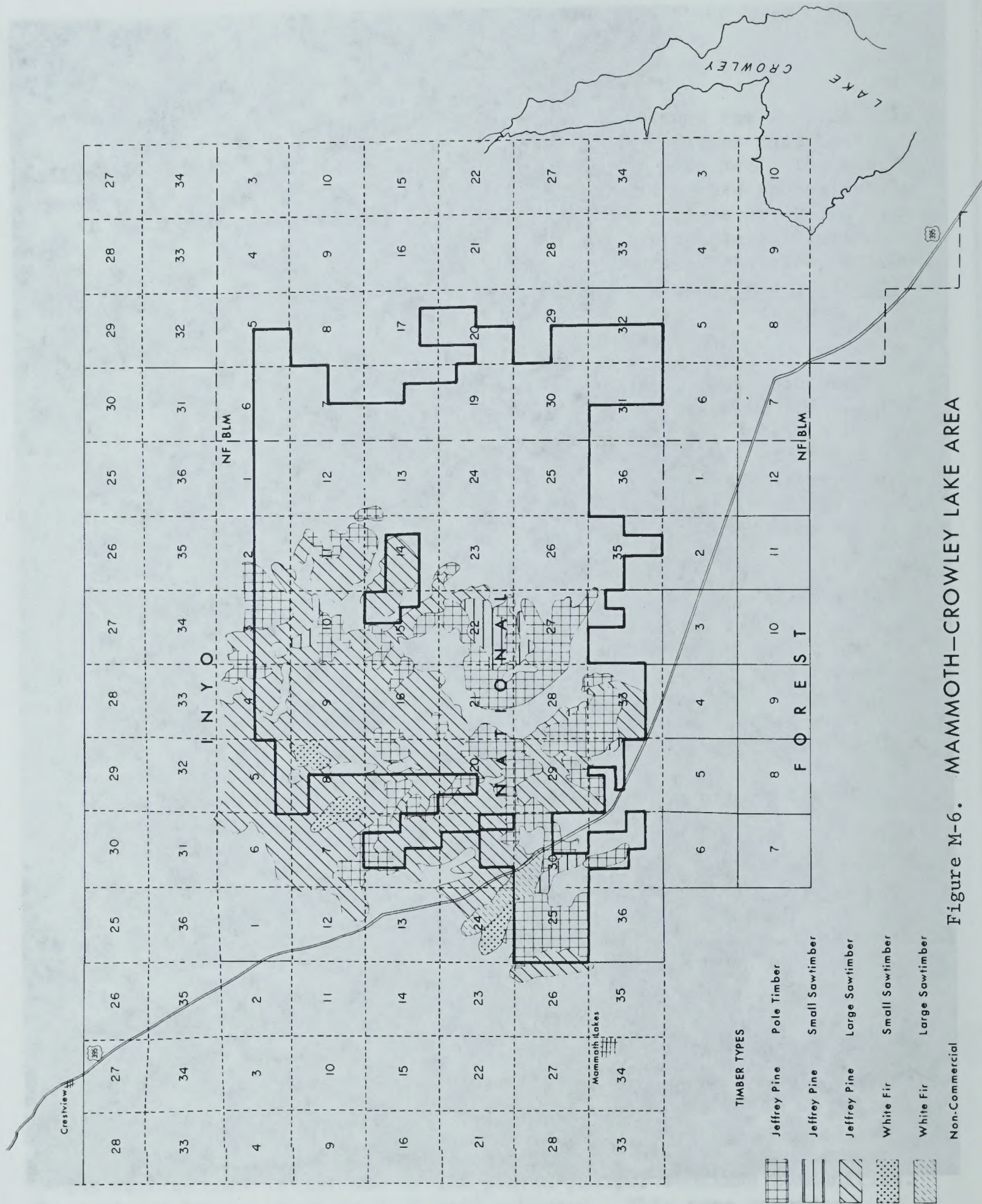


Figure M-6. MAMMOTH-CROWLEY LAKE AREA

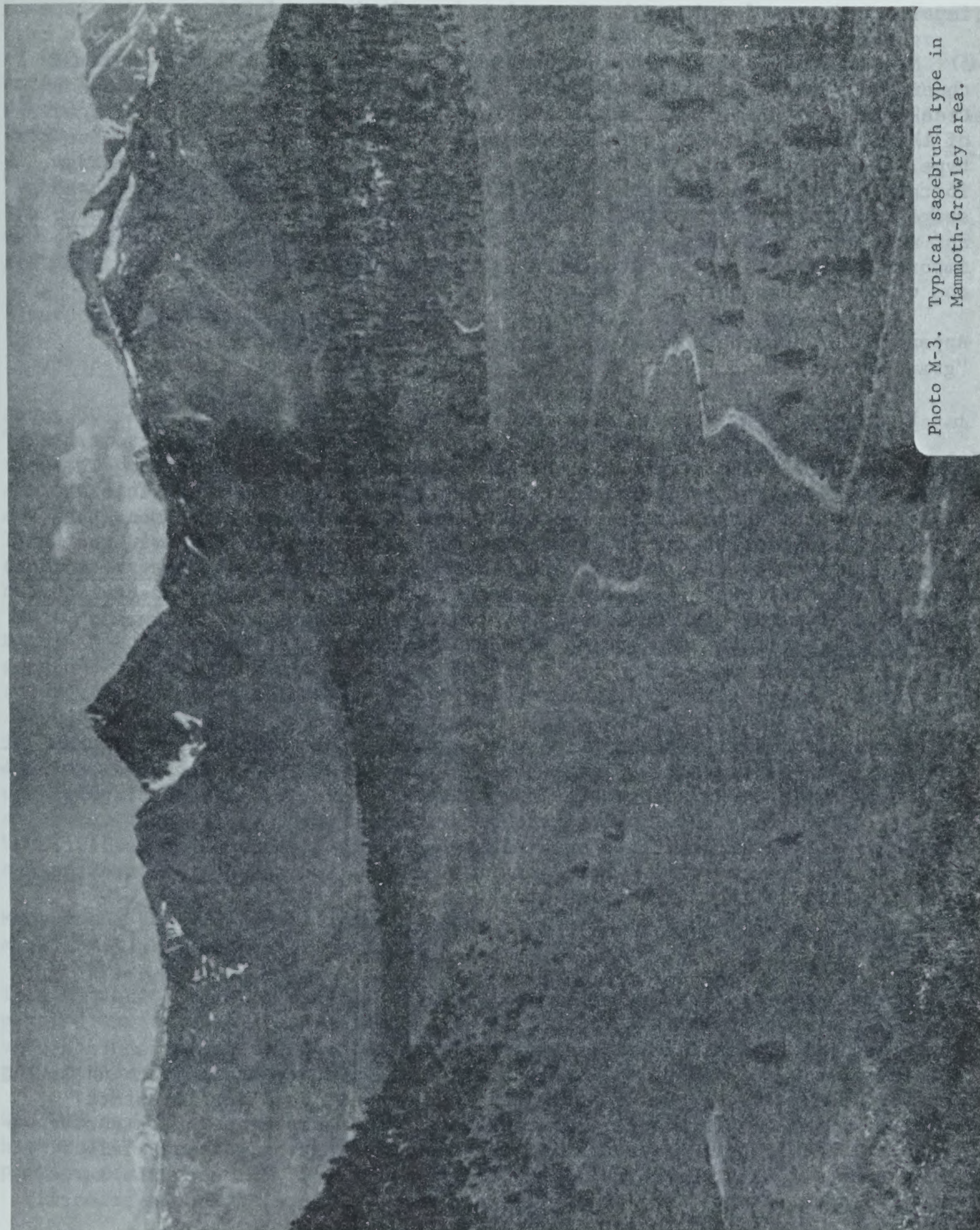


Photo M-3. Typical sagebrush type in  
Mammoth-Crowley area.

important browse for deer that summer in the "grandfather" area.

(5) Meadow-Grassland: This also includes riparian zones along the stream channels. Natural wet meadows are located along the Hot Creek, Little Hot Creek, Mammoth Creek, and Little Antelope Valley area. Extensive irrigation of these and adjacent areas has increased the acreage of this vegetative type. Some of the species found here are red-top (Agrostis alba), meadow foxtail (Alopecurus pratensis), tufted hairgrass (Deschampsia caespitosa), sedges (Carex spp.), wiregrass (Juncus spp.), monkey flower (Minulus spp.), and wild iris (Iris spp.). This vegetative community is one of the most important segments of the ecosystem in the "grandfather" area from a fish and wildlife standpoint due to its productivity of food and cover.

Appendix A lists the common plants found in the Mammoth-Crowley Lake "grandfather" area.

#### b. Mono Lake Area

The Mono Lake "grandfather" area is dominated by shrub communities. The most extensive type is the big sagebrush-bitterbrush community. This is typified by the large stands of this type on the south shore of Mono Lake between the shoreline and the Mono Craters. Other species found in the "grandfather" area are Jeffrey pine, western juniper, aspen (Poputremuloides) rabbitbrush, saltbush (Atriplex canescens), granite gilia (Leptodactylon pungens), locoweed (Astragalus spp.), lupine (Lupinus spp.), saltgrass (Distichlis stricta), and Indian rice grass (Oryzopsis humenoides).

(Appendix B lists all of the common plants of The Mono Basin)

The permanent alkali lakes provide both resting, feeding, and nesting habitat for many species of waterfowl and shore birds. American avocets, black-legged stilts, teal, and mallards nest along the grassy shores during the spring season. Great blue heron congregate here in the winter for feeding and resting. The workings of the aquatic systems within these ponds is little known at the present time. More detailed studies are needed to learn their relationships to the surrounding areas.

### 8. Land Use

#### a. Mammoth-Crowley Lake Area

The principal economic enterprise in the Mammoth-Crowley Lake "grandfather" area is grazing of domestic livestock. In the vicinity of Mammoth and Lake Crowley, the valley lands are sub-irrigated and are used for livestock grazing. Some 4,500 beef cattle and about 1,800 sheep graze on extensive pasture lands in this area and vicinity from late spring to early fall (Department of Water Resources Study of Long Valley). The mountain lands, owing to steep slopes, shallow soils, and a dry climate, are used primarily for rangeland grazing and as wildlife habitat.

Extensive recreational activities take place throughout the Mammoth-Crowley Lake area. The prime recreational activity is fishing on the large number of streams. Other recreation uses are hunting, camping, and hiking among the scenic mountains of the area, and winter sports--primarily skiing. Nature study, riding, rockhounding, and bottle hunting are other popular forms of recreation in this area.

Perhaps the major land use could be considered to be municipal watershed, since most of the runoff feeds the Owens Valley Aqueduct System of the City of Los Angeles. Some 80 percent of the city supply is obtained from this system.

Figure M-7 depicts special land uses in the Mammoth-Crowley Lake area.

(1) Timber

About 50 percent of the National Forest land within the Mammoth-Crowley Lake "grandfather" area is covered with commercial timber. (Figure M-6) The timbered portion lies on the westerly half of the area. Jeffrey pine is the dominant species with scattered white fir, lodgepole pine, single-leaf pinyon, and juniper. (Photo M-4) Most of the commercial stands are classified as large saw timber (larger than 21 inches diameter at breast height) and small areas are composed of small saw timber (11-20.9 inches diameter at breast height).

Figure M-8 shows proposed timber sales data. Large saw timber stands are generally poorly to medium stocked, meaning that volume per acre averages 4 thousand board-feet per acre. These stands, for the most part, are at rotation age and will be harvested over the next decade. One timber sale, in the northwest corner of the area under consideration, is proposed for logging in 1975. A new 10-year timber management plan currently is being prepared by the Forest Service. Preliminary indicates are that the annual allowable cut will be 6 million board feet instead of the current 8.2 million board feet. This could result in a slower rate of timber harvest within and adjacent to the "grandfather" area.

Many roads have been constructed in the forested portions of the "grandfather" area for timber management purposes.

In addition to the commercial logging, commercial and free use fuel wood permits amounted to an additional 4 million board feet of timber in fiscal year 1973 on the northern part of the forest. Most of the fuel wood is gathered in logged areas.

Wood is the major source of heating in the nearby communities, due to the high cost of importing organic fuels and electricity. More than 1,100 permits for wood were obtained in fiscal year 73. There is a possibility



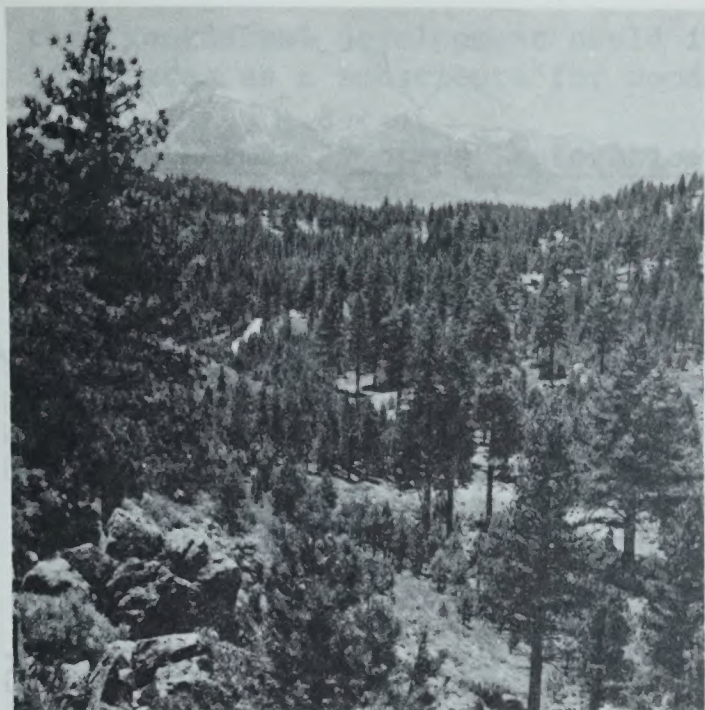


Photo M-4. Coniferous Forest Habitat

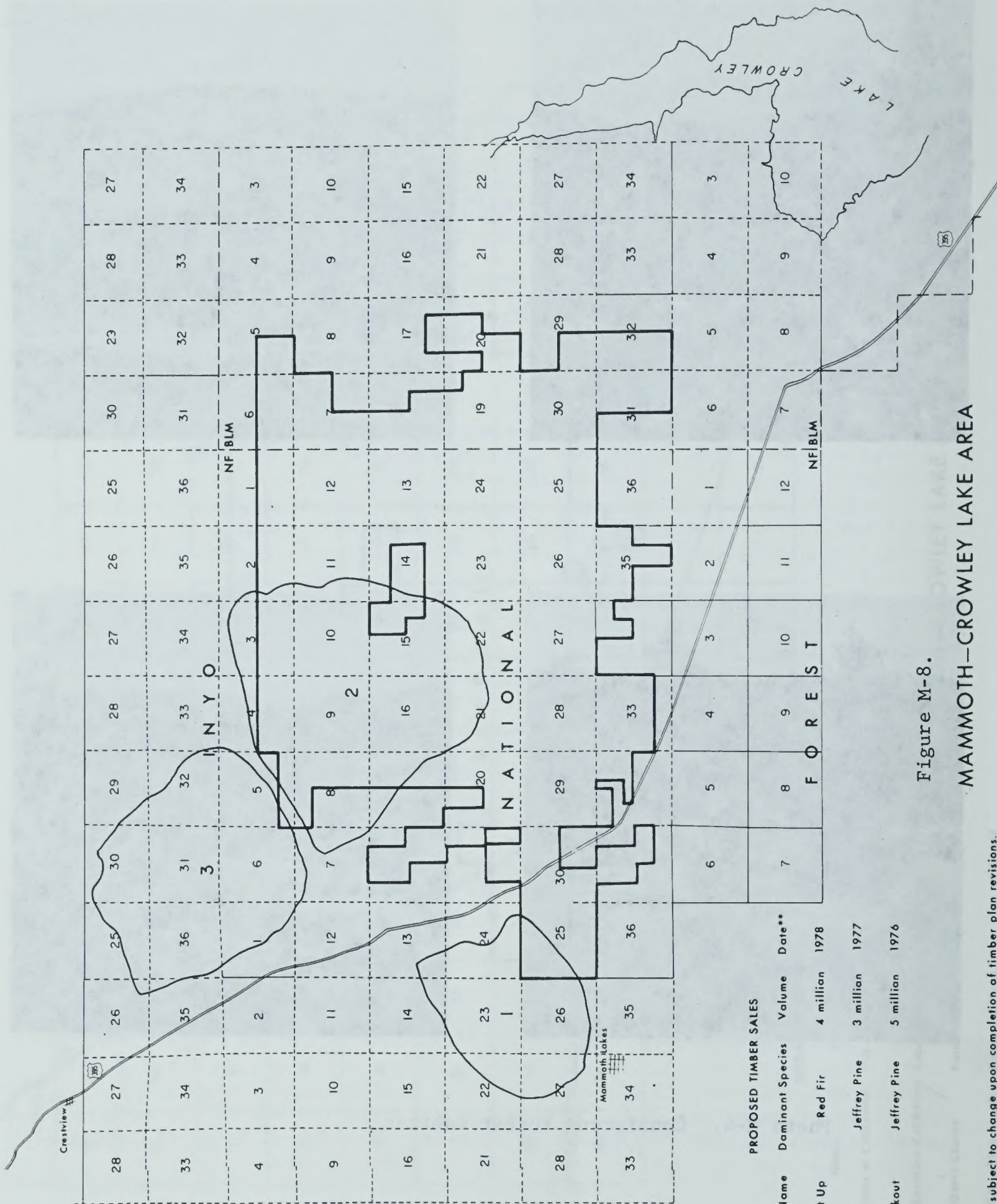


Figure M-8.

# MAMMOTH-CROWLEY LAKE AREA

\*\*Dates subject to change upon completion of timber plan revisions.

that geothermal development could include providing heat energy for the local area as a substitute for wood.

## (2) Geothermal Resource Exploration

The major exploration efforts in the Mammoth-Crowley Lake "grandfather" area to date have been in the vicinity of Casa Diablo Hot Springs in Sec. 32, T. 3S., R.28E., near the Mammoth Creek crossing of U.S. Highway 395. (Photo M-5) Since the late 1950's, 10 relatively shallow wells have been drilled in this vicinity, all producing hot water.

McNitt (1963) gives data on 4 wells drilled to depths of 570, 630, 810, and 1,063 feet. (Table M-3) The maximum temperature recorded in the wells ranged from 132°C. to 181°C., the pressure ranged from 7.5 to 39 p.s.i.g., steam produced ranged from 19,000 to 69,000 lbs./hour, and the hot water produced ranged from 233,500 to 473,000 lbs./hour. The silica dissolved in the well fluids suggest a reservoir temperature of at least 185-190°C.

## (3) Grazing.

All national resource lands under the administration of the Bureau of Land Management in the "grandfather" area are covered by grazing allotments. Figure M-9 outlines the grazing allotments for the Mammoth-Crowley Lake area. The Hot Creek allotment includes the southern portion of the area, and carries 107 animal months, from 6/16 - 9/30. The Cashbaugh individual allotment, in the northern portion, has 397 animal months of use, from 4/1 - 10/31.

With few exceptions, all the national forest land within the "grandfather clause" portion of the KGRA is covered by grazing allotments. The Hot Creek allotment in the southern portion of the area carries 805 animal months, from 6/20 to 3/30. The Antelope allotment, covering the northern portion of the area, has 450 animal months of use. from 6/20 to 8/13. In addition, the southwest corner of the "grandfather" area is part of the Sherwin sheep allotment. This allotment carries 2,000 sheep from 6/16 to 7/3. A special use pasture permit is issued to Gerry Chance for 100 acres. It carries 45 animal months.

Grazing on the national forest portion of the Mammoth-Crowley Lake "grandfather" area goes back many years and is well established. One of the original ranger stations was located in Little Antelope Valley and was established primarily for management of sheep.

The sheep are well herded during their brief stay in the area. Cattle however, range widely but are concentrated in the sagebrush areas on the eastern side of the area plus a few well watered areas such as Little Antelope Valley, where a constant supply of water is available. Photo M-6 shows a typical grazing area. This is also a sage grouse strutting area.

Photo M-5. Casa Diablo Hot Springs,  
Sec. 32, T.3 S., R.28 E., M.D.M.

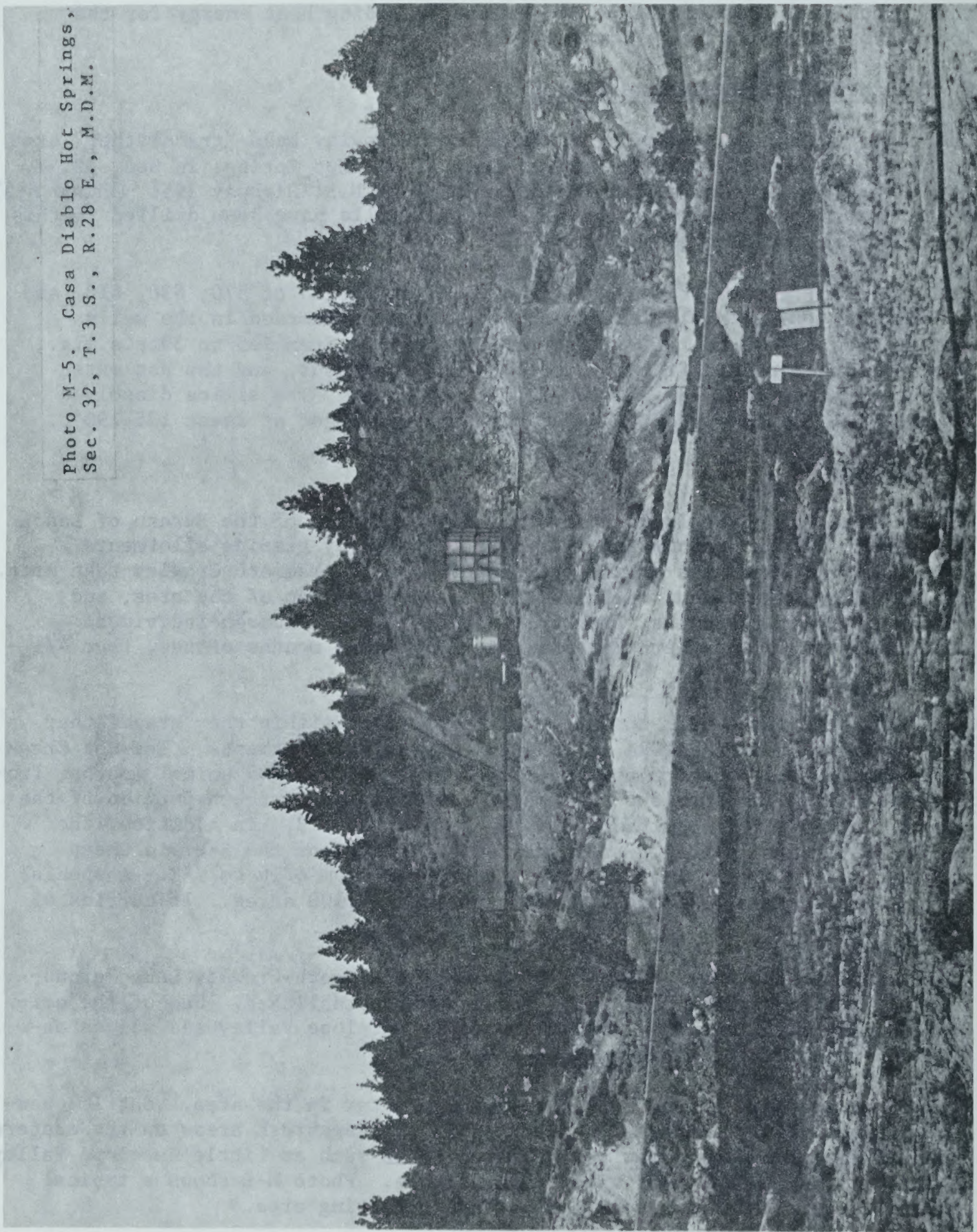


Table M-3. Chemical constituents of fluids from Casa Diablo wells in ppm (after McNitt, California Division of Mines and Geology, Special Report 75, 1963)

	Endogenous No. 1 <sup>b</sup>	Endogenous No. 2 <sup>a</sup>	Endogenous No. 2 <sup>b</sup>	Mammoth No. 1 <sup>a</sup>	Endogenous No. 4 <sup>c</sup>	Endogenous No. 4 <sup>d</sup>
Silica	250	278	256	292	200	0.8
Calcium	--	2	--	30	4	--
Magnesium	--	trace	--	trace	--	--
Sodium	380	236	375	247	308	5
Potassium	47	62	45	71	32	--
Lithium	--	4	--	3	0.3	--
Iron	--	5	--	4	--	--
Aluminum	--	2	--	1	--	--
Boron	--	60	--	49	11	0.3
Chloride	276	266	276	301	227	5
Sulfate	61	108	62	124	96	2
Hydrogen Sulfide	--	--	--	--	14	11
Fluoride	--	--	--	--	20	--
Arsenic	--	--	--	--	0.2	--
Ammonia	--	--	--	--	0.1	0.5
Carbon Dioxide	--	--	--	--	180	205

Analyst: Abbot A. Hanks, Inc., San Francisco

- Sample taken from wellhead immediately after flowing. Some water flashed to steam.
- Sample taken from wellhead after cooling. No flashing to steam.
- Water sample taken during flow test.
- Condensate of steam sample taken during flow test.

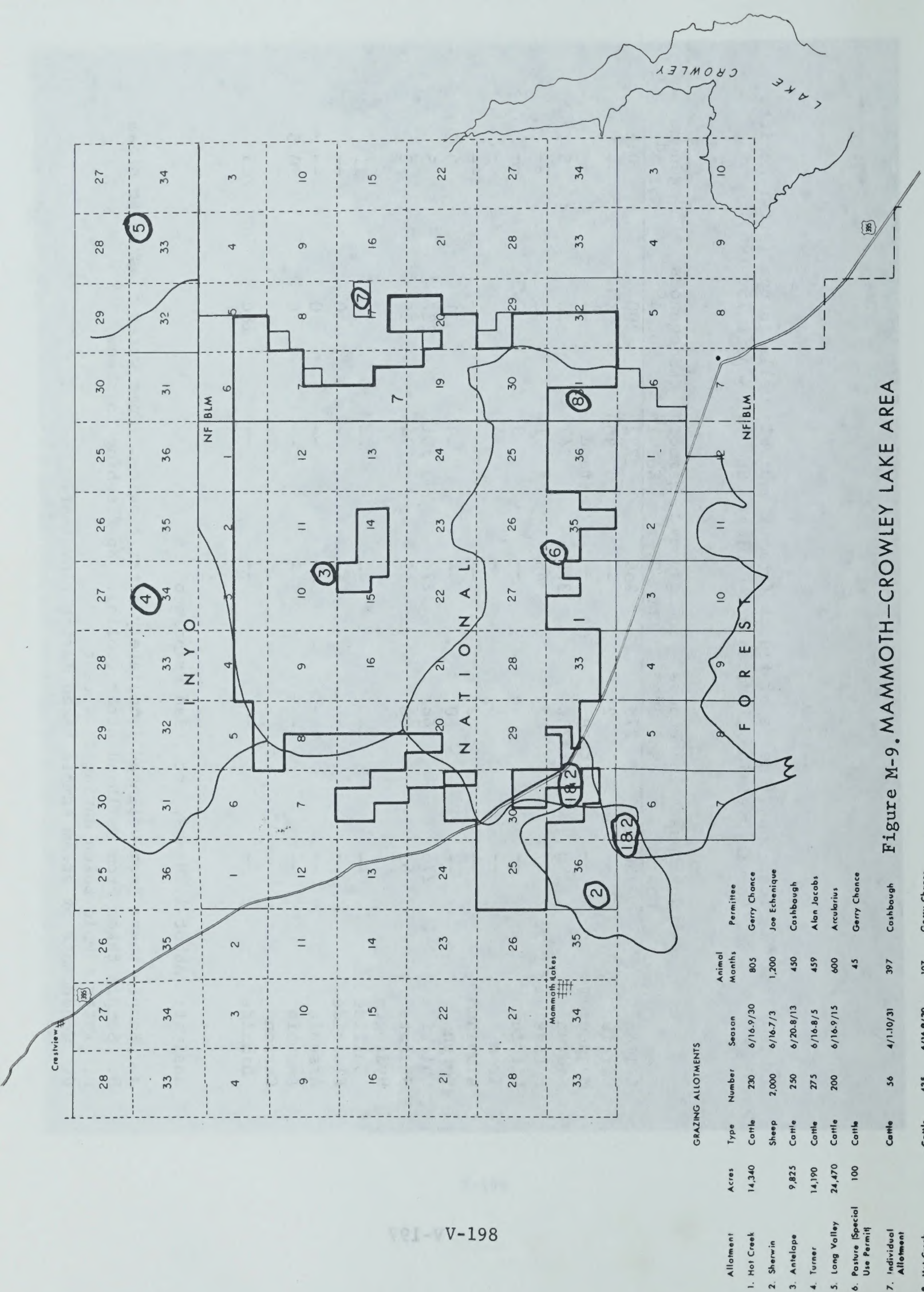


Figure M-9. MAMMOTH-CROWLEY LAKE AREA

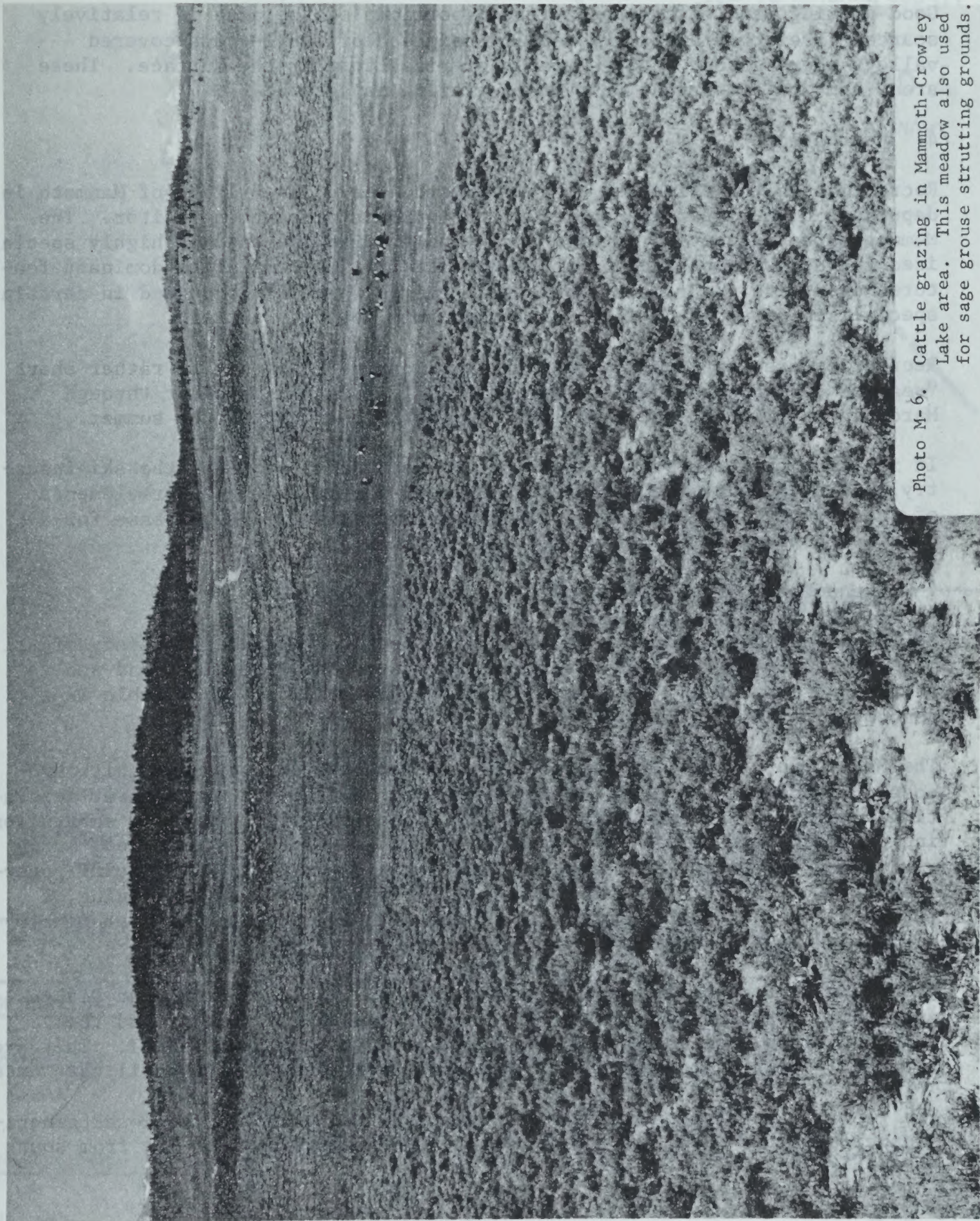


Photo M-6. Cattle grazing in Mammoth-Crowley Lake area. This meadow also used for sage grouse strutting grounds.

Good grazing land within the forested portions of the area is relatively scarce. Preferred areas are usually composed of small grass-covered valleys where ground water surfaces or rises to near the surface. These areas are most important to overall grazing management.

#### (4) Recreation

Recreation is the prime use of the Mammoth Area. The Village of Mammoth is dependent both winter and summer on the outdoor recreation visitor. The Mammoth area economy is a very narrow and fragile one that is highly specialized and not well-balanced. These characteristics remain its dominant features even with the recent substantial growth which has occurred in certain specialized portions of its overall economic activity pattern.

Recreation use has grown rapidly and visitors peak sharply in rather short "seasons", both winter and summer--typically from mid-December through March in the winter, and from late July through August in the summer.

It is clear that the basic income of the recreation economy, the ski industry, has attained the critical size needed to sustain the other elements of the economy. The result is a viable, if fragile, economic base for a developing new town in a recreational setting.

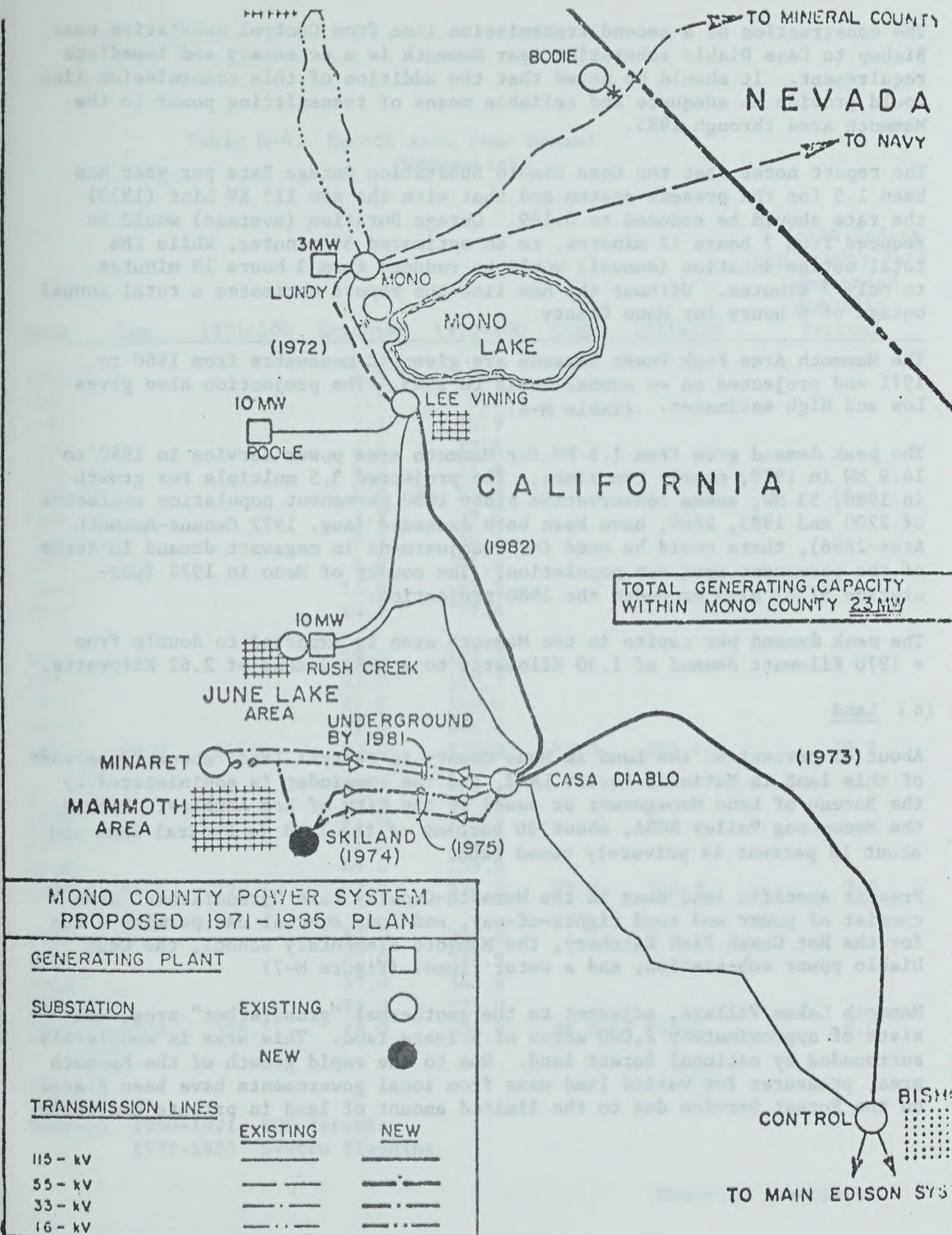
#### (5) Transmission Facilities and Present Power Plants.

Southern California Edison has produced a detailed engineering study of all of Mono County and related service centers served by the lines and substations of the area. The Mammoth area's substation at Casa Diablo is a component detailed in the report.

The Mono County Power System is illustrated on the following map with proposed developments to 1985. (Figure M-10) Shown are the three power generating capacity of 23 megawatts. Also shown are the eight existing substations including the two serving the Mammoth area (Casa Diablo and Minaret) along with a new substation in Mammoth called Skiland (1974). The existing powerlines from Bishop-Control are shown, 115KV as far north as Lee Vining, a proposed 115 KV line by another route for 1973 construction to Casa Diablo and on to Lee Vining (1982).

Of special interest are proposed underground 33 KV lines from Casa Diablo and Skiland sub, scheduled for 1975, and a proposal to underground the existing lines from Casa Diablo to Mammoth and Minaret sub (1981). They are apparently waiting to observe the Skiland underground system until that date.

The report states that Mono County power load had exceeded the local generation capacity in 1970, and future power requirements will be met from south of Bishop.



MONO COUNTY POWER SYSTEM PROPOSED 1971-1985 PLAN			
<u>GENERATING PLANT</u>			
<u>SUBSTATION</u>	EXISTING		
	NEW		
<u>TRANSMISSION LINES</u>			
	EXISTING	NEW	
115 - kV	=====	=====	
55 - kV	-----	-----	
33 - kV	.....	.....	
16 - kV	.....	.....	
SOUTHERN CALIFORNIA EDISON COMPANY SYSTEM PLANNING SEPTEMBER 1972			

Figure M-10.

The construction of a second transmission line from Control substation near Bishop to Casa Diablo substation near Mammoth is a necessary and immediate requirement. It should be noted that the addition of this transmission line would provide an adequate and reliable means of transmitting power to the Mammoth area through 1985.

The report notes that the Casa Diablo Substation Outage Rate per year has been 1.5 for the present system and that with the new 115 KV Line (1973) the rate should be reduced to 0.169. Outage Duration (average) would be reduced from 2 hours 12 minutes, to an estimated 39 minutes, while the total outage duration (annual) would be reduced from 3 hours 19 minutes to only 7 minutes. Without the new line the report estimates a total annual outage of 6 hours for Mono County.

The Mammoth Area Peak Power Demands are given in megawatts from 1960 to 1971 and projected on an annual basis to 1985. The projection also gives Low and High estimates. (Table M-4)

The peak demand grew from 1.5 MW for Mammoth area power service in 1960 to 14.9 MW in 1970, nearly ten times. The projected 3.5 multiple for growth in 1980, 53 MW, seems conservative since 1980 permanent population estimates of 2200 and 1985, 2800, have been both exceeded (Aug. 1972 Census-Mammoth Area-2886), there could be need for readjustment in megawatt demand in terms of the permanent resident population. The county of Mono in 1972 (population 5738) also exceeded the 1980 projection.

The peak demand per capita in the Mammoth area is expected to double from a 1970 Kilowatt demand of 1.30 Kilowatts to a 1980 demand of 2.62 Kilowatts.

#### (6) Land

About 81 percent of the Land in Mono County is Federal land; about 73 percent of this land is National Forest Land, and the remainder is administered by the Bureau of Land Management or owned by the City of Los Angeles. Within the Mono-Long Valley KGRA, about 90 percent of the land is Federal land and about 10 percent is privately owned land.

Present specific land uses in the Mammoth-Crowley Lake "grandfather" area consist of power and road rights-of-way, and four special use permits - one for the Hot Creek Fish Hatchery, the Mammoth Elementary School, the Casa Diablo power sub-station, and a water flume. (Figure M-7)

Mammoth Lakes Village, adjacent to the geothermal "grandfather" area, consists of approximately 2,000 acres of private land. This area is completely surrounded by national forest land. Due to the rapid growth of the Mammoth area, pressures for varied land uses from local governments have been placed on the Forest Service due to the limited amount of land in private ownership.

Table M-4. Mammoth Area Peak Demand  
(Megawatts)

Year	Low	1971=100	Expected	1970=100	High	1971=100	5 Years Ending Avg Growth Rate Compounded Annually
							Percent
1960			1.5	7.8			
1961			1.7	8.8			
1962			2.1	10.9			
1963			2.4	12.5			
1964			4.2	21.8			
1965			4.9	25.5			26.7
1966			7.2	37.5			
1967			7.7	40.1			
1968			9.8	51.0			
1969			11.0	57.2			
1970			14.9	77.6			
1971			19.2	100.0			
1972			23.0	119.7			
1973			27.0	140.6			
1974			31.0	161.4			
1975	28.0	145.8	34.0	177.0	39.0	203.1	17.9
1976			38.0	197.9			
1977			41.0	213.5			
1978			45.0	234.3			
1979			49.0	255.2			
1980	44.0	229.1	53.0	276.0	67.0	348.9	9.3
1981			57.0	296.8			
1982			62.0	322.9			
1983			67.0	348.9			
1984			72.0	375.0			
1985	63.0	328.1	78.0	406.2	99.0	515.6	8.0

Source: 1960-1971 SCE Records  
1972-1985 System Planning

Monoplan Associates

Most land owned by City of Los Angeles is leased for cattle grazing. Leases are required to permit hunting and fishing by the general public. The Forest Service in 1971 joined with Mono County and contracted with a group of land planners for an area land use plan for the Mammoth-Long Valley area. The Mammoth-Crowley Lake "grandfather" area is completely within this study area. The plan is being financed by Mono County, under a comprehensive planning grant from the Department of Housing and Urban Development, and by the Forest Service. To date, the Mono Plan has established an environmental base line and inventory, as well as developing some land use alternatives for the area.

## (7) Cultural Uses

There were several groups of Paiute Indians living in the vicinity at the time the first white men visited the area. These people utilized the natural products of the land for their subsistence, including pine nuts, deer, rabbits, pandora moth caterpillars, indian rice grass, chia fly larvae, and many other seeds, roots, and animals. Periodic trips were made from village sites to gather these items in season. Today Paiutes still are living on a reservation near Bishop and in Lee Vining, and they still use the Long Valley area, principally to gather pine nuts and other products like roots, and basketry material. There also are traditional use areas where graves of their friends and relatives are located. Several old cemeteries are in the area. Examples are the Paiute cemetery in the vicinity of Lower Hot Creek and an old cemetery near Mono Vista Spring. Undoubtedly, other associations with old mining areas and ranch activities are scattered throughout the area.

Aspen groves are scattered throughout the area. Carvings made by Basque and Spanish sheepherders, on aspen trees are now considered a primitive art form.

### b. Mono Lake Area

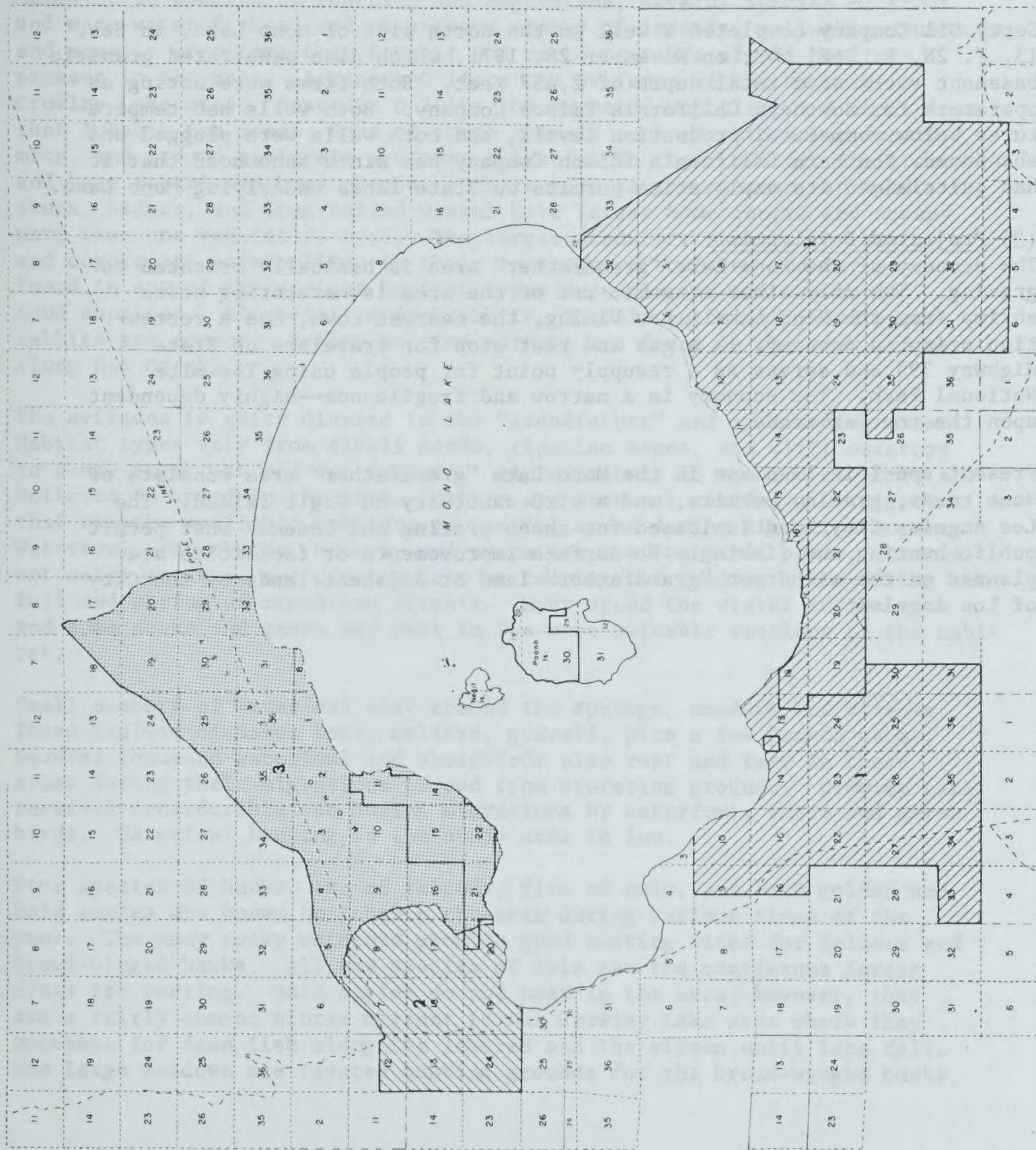
#### (1) Grazing

The principle economic enterprise in the Mono Lake "grandfather" area is sheep grazing. The Mono Lake area grazing allotments with type of livestock, number, and season are shown on Figure M-11. Livestock grazing is not authorized on Pahoa Island.

The Mono Basin land is principally national resource land under the administration of the Bureau of Land Management. Scattered tracts of privately-owned land, generally not comprising more than two square miles in a continuous tract, are found in the Mono Basin. The State of California owns the lands beneath Mono Lake.

#### (2) Geothermal Resource Exploration

In the spring of 1971, the California State Lands Commission issued leases



# GRAZING

Allotment	Mono Mills
Type	Sheep
Number	990
Season	6/1/10/30
Animal Months	148
Permittee	Joe Mandibure
Allotment	Mono Settlement
Type	Sheep
Number	1,600
Season	6/1/10/31
Animal Months	240
Permittee	Mono Sheep Co.
Allotment	DeChambers Ranch
Type	Sheep
Number	1,000
Season	6/1/8/15
Animal Months	500
Permittee	Soldashere Bros.

MONO LAKE AREA  
Figure M-11.

and permits to Southern California Edison Company, to prospect for geothermal resources on seven parcels of State-owned land. Six parcels comprised submerged lands in Mono Lake, and one covered an area of State school land, adjacent to the lake. A well, drilled by Geothermal Resources International Inc., on the south side of Mono Lake, in Section 17, T. 1N, R. 27E, MDM was completed in granitic basement rocks on September 25, 1971, at a total depth of 4,110 feet with a bottom note temperature of 150°C.

Getty Oil Company completed a well on the north side of Mono Lake, in Sec. 13, T. 2N, R. 26E, MDM; on November 28, 1971, which also penetrated granitic basement rocks at a total depth of 2,437 feet. Both firms were acting as operators for Southern California Edison Company. Both wells had temperatures below commercial production levels, and both wells were plugged and abandoned. Southern California Edison Company has since announced that it has quitclaimed its exploration permits on State lands underlying Mono Lake.

### (3) Projected Development.

The economy of the Mono Lake "grandfather" area is basically oriented to grazing. The only other economic use of the area is harvesting brine shrimp from the Mono Lake. Lee Vining, the nearest town, has a recreation oriented economy, is a gas and rest stop for travelers on State Highway 395 and serves as a resupply point for people using Yosemite National Park. The economy is a narrow and fragile one--highly dependent upon the tourist trade.

Present specific land use in the Mono Lake "grandfather" area consists of some roads, grazing permits, and a bird sanctuary on Negit Island. The Los Angeles City land is leased for sheep grazing and lessees must permit public hunting and fishing. No surface improvements or facilities are planned on the withdrawn "grandfather" land or adjacent lands by the City of Los Angeles.

## 9. Fish and Wildlife

### a. Mammoth-Crowley Lake

The fish and wildlife resources in the Mammoth-Crowley Lake area are quite varied for an area that has large areas of rather homogeneous habitat types. There are at least 95 species of birds, 60 species of mammals, 10 species of reptiles and amphibians, several species of trout and warm water fishes, and an unknown number of insects, mollusks, crustacea, and aquatic organisms that inhabit and various niches of the habitats present in the area. Appendix C lists the avifauna of the Mammoth-Crowley Lake area. Appendix D lists the mammals, reptiles, and amphibians that inhabit the area. Some of these animals such as chipmunks, meadow mice, and ground squirrels are very selective in their habitat preferences and have restricted home ranges. Others such as the raccoon, striped skunk, badger, and long-tailed weasel have larger home ranges and occupy more than one vegetative type. The larger predators such as the bobcat and coyote are cosmopolitan in their coverage of the area and may be found in any of the various habitat types depending on the available food supplies. Black-tailed jackrabbits, Nuttall cottontail, and pygmy rabbits are common. Yellow-bellied marmots are found in the rock ledges along Hot Creek.

The avifauna is quite diverse in the "grandfather" and surrounding areas. Habitat types vary from alkali ponds, riparian zones, and cliff outcrops to dense sagebrush and wet meadows. Approximately 40 species of birds are believed to breed in the area. Others are seasonal residents or migrants that use the available habitats as resting areas during migration movements. Waterfowl, shorebirds, cranes, and swans use the scattered ponds, streams, hot water springs, and Crowley Lake as resting and feeding areas during the fall and spring of migration flights. Many spend the winter in the area and some ducks and geese may nest in the more suitable sections of the habitat.

Small numbers of waterfowl nest around the springs, meadows, and streams. These include cinnamon teal, mallard, gadwall, plus a few Canada geese. Several thousand waterfowl and shorebirds also rest and feed in these areas during their migrations to and from wintering grounds. Crowley Lake receives considerable use during migrations by waterfowl, shore and marsh birds. Waterfowl hunting in the study area is low.

Five species of hawks, two of falcons, five of owls, and both golden and bald eagles are known to inhabit the area during various times of the year. The many rocky outcrops provide good nesting sites for falcons and broad-winged hawks. All the species of owls use the coniferous forest areas for nesting. Bald eagles do not nest in the area; however, they are a fairly common winter migrant in the Crowley Lake area where they scavenge for dead fish along the lakebed and the stream until late fall. The large meadows are favored hunting grounds for the broad-winged hawks,

marsh hawks, and sparrow hawks. Cooper's hawks are commonly observed in the coniferous forest and the pinyon-juniper woodland where they hunt for small birds.

The game birds that inhabit the area include mourning dove, valley quail, bandtailed pigeon, and sage grouse. The wildlife and habitat map, shown in Figure M-12, depicts vegetative cover, waterfowl nesting and resting areas, sage grouse sites, and deer migration routes for the Mammoth-Crowley Lake area. Sportsmen prefer mourning dove and sage grouse, but bandtails and quail are eagerly sought during good brood years. The occurrence of band-tails is sporadic in the Mammoth area, depending on food supplies. The most popular bird in Mono-Long Valley area is the sage grouse. The Crowley Lake basin supports one of the few remaining sage grouse populations within the State of California. The population has been decreasing during the past decade due to loss of habitat through vegetative type conversion, human encroachment, and a high harvest during special hunting seasons.

Sage grouse are found over a wide area in association with extensive stands of sagebrush and the presence of meadows and water. This bird is more dependent on specialized environment than any other game bird in the United States. The diet of adult birds is almost exclusively sagebrush leaves in the spring and summer and exclusively during the critical winter season.

The second largest concentration of sage grouse in Mono-County is located in the vicinity of Crowley Lake. Courtship usually takes place on areas called "strutting grounds" during March and April along the edge of meadows in areas of short sagebrush. Photo M-6 shows a sage grouse strutting ground located in a meadow surrounded by sage brush. The courtship rites of the sage grouse attracts many tourists. At least three active strutting grounds plus nesting areas, feeding and loafing grounds are located in the grandfather area. One area near Hot Creek has not been used for many years, possibly due to excessive human disturbance. Most nesting occurs in May and June, within one mile of wet meadows or streams. During the brood rearing period from June to September, tall sage adjacent to meadows is an important escape cover. During severe winters, the Crowley Lake birds move a few miles east to spend the winter. Although the hunting season may only be one or two days, hunting is intensive.

Although, mourning doves are popular with hunters, most of the birds leave the area prior to the opening of the season due to cold weather. Doves nest in the area during the spring and early summer season so, the area represents important habitat for the species.



Due to its value as a game species, the most popular mamal in the area is the mule deer. The "grandfather" area is within the range of the Casa Diablo deer herd. Deer from this herd summer in the high elevation areas along the Sierra Nevada crest and move eastward to Casa Diablo Mountain, Banner Ridge, and south to Sherwin Grade during the winter season. Many deer move through the "grandfather" area for short time periods. However, there are small family groups that utilize the suitable browse habitats and spend the summer season in the area. (Photo M-3)

Major streams in the study area, or the surrounding area of influence, are tributary to Crowley Lake. These include Hot Creek, Mammoth Creek, and Owens River. Hot Creek from the Hot Creek Fish Hatchery downstream about four miles to the gorge is one of the best trout fishing streams in the state. This section is classified as a Wild Trout Stream by the Fish and Game Commission of California and fly fishing only is allowed. Both Mammoth and Hot Creeks contain self-sustaining populations of mostly brown trout while rainbow trout are supplemented by stocking from the Hot Creek Fish Hatchery operated by the California Department of Fish and Game. The relatively constant temperature of 58°F from cold water springs is ideal for rearing trout. This hatchery is unique in that eggs from a fall spawning rainbow trout developed here are supplied to other trout hatcheries in California. About one million catchable-sized rainbows are stocked in Mono and Inyo Counties. Currently fishing use in the four mile stream is about 6,500 angle days annually. Some fishing also occurs downstream. Annual fishing use along Mammoth Creek is about 5,000 angler days. The lower reach of Hot Creek also contains non-game fishes, including the probable existence of the Owens chub which is currently being considered for inclusion on the endangered species list.

The Owens River and Crowley Lake also contain populations of suckers, chubs, dace, and Sacramento perch. Crowley Lake is an excellent fishery for rainbow trout while other fish caught include brown trout and Sacramento perch. Some trout are also caught in the Owens River above the lake. Several unique hot spring ecosystems, such as those around Little Hot Creek and Whitmore hot springs support populations of dace and chubs.

The Hot Creek drainage is considered a unique aquatic ecosystem. (Photo M-7) The warm waters below the hot springs provide an abundance of benthic organisms that allow trout to reach trophy size. The warm waters also remain ice-free during the winter and provide feeding and resting areas for many species of waterfowl and shore birds. The area also provides a winter source of food for predators that inhabit the area. The riparian zones along the stream course are favored nesting grounds for both song birds and shore birds during the spring and early summer seasons. The vegetative growth also supports many small herbivores that are the primary source of food for both terrestrial and aerial predators. The warm water springs are one of the favored recreational spots for visitors to the Mammoth area during both the summer and winter periods. (Photo M-8)



Photo M-7. Hot Creek in the southern portion of the Little Antelope Valley, Mount Laurel in background. (Photography by Mary R. Hill, California Division of Mines and Geology).

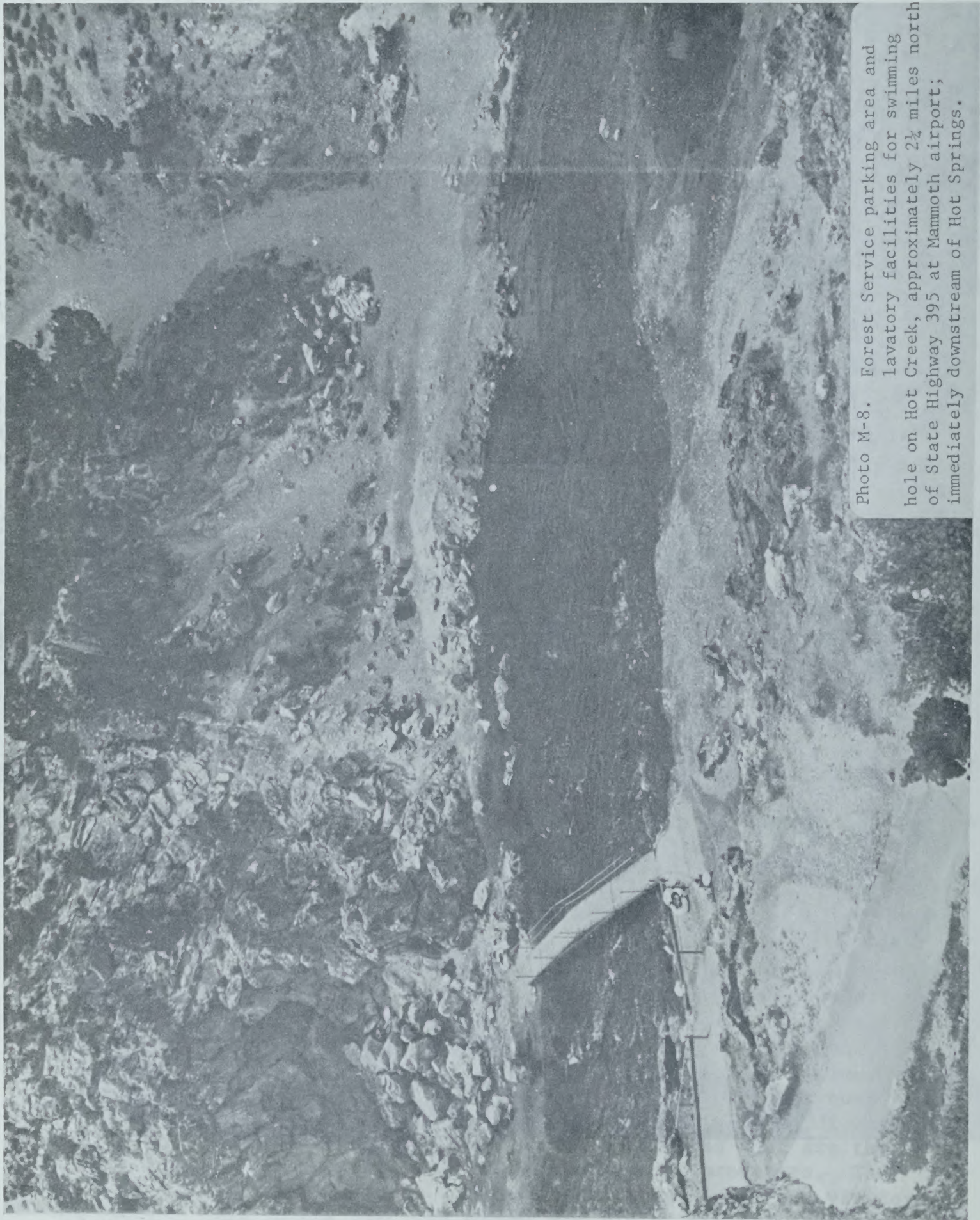


Photo M-8. Forest Service parking area and lavatory facilities for swimming hole on Hot Creek, approximately 2½ miles north of State Highway 395 at Mammoth airport; immediately downstream of Hot Springs.

At least ten species of reptiles and amphibians are found in the various habitat types within the "grandfather" area. Detailed data on distribution and abundance is lacking for the area at this time. Detailed studies are needed to learn more about the habitat requirements and ecological relationships of those species.

The aquatic systems within the scattered hot springs and alkali ponds are virtually unknown at the present time. The workings of these systems and their relationships to the fauna of the entire area should be studied.

#### b. Mono Lake Area

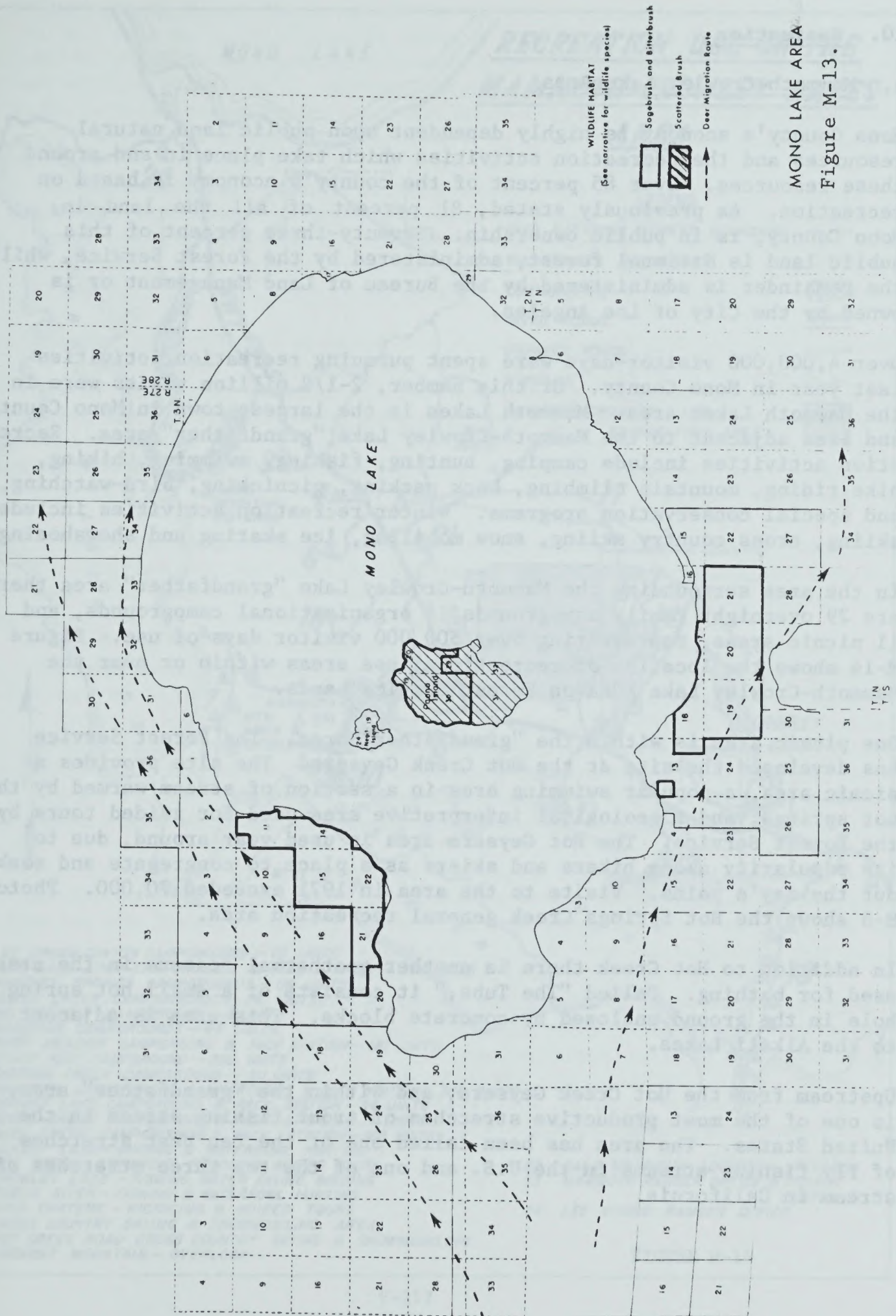
Historically, the runoff from Mill, Lee Vining, Walker, Parker, and Rush Creeks flowed into Mono Lake. The diversion of virtually the entire runoff from these streams into the Los Angeles water system has resulted in the rapid decline of the lake level during recent years. At present, the water in Mono Lake contains twice the dissolved salts as sea water, and cannot support fish life; however, microscopic flora and fauna are present in the lake: including phytoplankton, zooplankton, flagellates, diatoms, and green algae. Brine shrimp (Artemia salina) inhabit the lake in large numbers and are harvested commercially for tropical fish food. This particular species of brine shrimp is thought to be physiologically distinct from other Western populations of brine shrimp (Mason, 1967).

A large number of shore birds and waterfowl use the lake as a resting, feeding, and nesting area. Thousands of eared grebes, phalaropes, American avocets, common snipe, some whistling swans and spotted sandpipers move through the area during the July-September period. Fairly large number of pintail, gadwall, cinnamon teal, Canada geese, ruddy duck, and shoveller are present on the lake in September and October. The heaviest use occurs during the fall migration period. As many as 100,000 birds of various species have been reported to be on the lake at one time by local bird watching enthusiasts. Appendix E lists birds observed in the Mono-Lake area.

There are two islands in the lake that support both mammalian and avian populations. The large island, Paoha Island, has several fresh water springs and marshy areas that are used as nesting grounds by American avocets, killdeer, blackbirds, and sandpipers. Several species of rodents are also on this island. A small number of feral goats left from an early 1920 era ranching operation still inhabit the island. Negit Island, a small volcanic island lying just north of Paoha Island, supports one of the largest seagull rookeries on the West coast. The principle nesting specie is the California gull; however, Caspian tern and ring-billed gulls occasionally nest on the island. The gulls begin to arrive in late April and reach a high point by the first of June. Nesting occurs from mid-May to early July. At the peak of the nesting season there are thousands of gulls in the Mono Lake-June Lake area; however this tapers off in late summer. Gulls are present in the winter but in very low numbers.

Negit Island was designated as a natural area pursuant to the authority in 43 CFR Subparts 2070 and 6225. Negit Island is a Class IV "Outstanding Natural Area" under the Bureau of Outdoor Recreation system of classification. Specifically, the notice of designation states the land shall not be used, occupied, constructed upon, or improved in a manner inconsistent with the purpose for which the area is established (Federal Register Doc. 72-15242 filed 9-7-72).

The terrestrial population of mammals in the Mono Lake "grandfather" area is similar to that in the comparable habitat types found in the Mammoth-Crowley Lake "grandfather" area. Although not present in the "grandfather" area, the Mono Lake deer herd that summers west of the lake migrates either through the area or nearby, about October 1, enroute to their winter range in Nevada. These deer begin their return to summer range about April 1. Figure M-13 shows the major areas of sagebrush-bitterbrush stands and other types of brush along with deer migration routes.



## 10. Recreation

### a. Mammoth-Crowley Lake Area

Mono County's economy is highly dependent upon public land natural resources and the recreation activities which take place in and around these resources. Over 85 percent of the county's economy is based on recreation. As previously stated, 81 percent of all the land in Mono County, is in public ownership. Seventy-three percent of this public land is National forest, administered by the Forest Service, while the remainder is administered by the Bureau of Land Management or is owned by the City of Los Angeles.

Over 4,000,000 visitor-days were spent pursuing recreation activities last year in Mono County. Of this number, 2-1/2 million visits were in the Mammoth Lakes area. Mammoth Lakes is the largest town in Mono County and lies adjacent to the Mammoth-Crowley Lake "grandfather" area. Recreation activities include camping, hunting, fishing, swimming, hiking, bike riding, mountain climbing, back packing, picnicking, bird-watching, and special conservation programs. Winter recreation activities include skiing, cross country skiing, snow mobiling, ice skating and showshoeing.

In the area surrounding the Mammoth-Crowley Lake "grandfather" area there are 29 overnight family campgrounds, 8 organizational campgrounds, and 11 picnic areas, representing over 500,000 visitor days of use. Figure M-14 shows the location of recreational use areas within or near the Mammoth-Crowley Lake KGRA on Forest Service Lands.

One picnic area is within the "grandfather" area. The Forest Service has developed the site at the Hot Creek Geysers. The site provides a picnic area, a popular swimming area in a section of stream warmed by the hot springs, and a geological interpretive area used for guided tours by the Forest Service. The Hot Geysers area is used year around, due to its popularity among hikers and skiers as a place to congregate and soak out the day's pains. Visits to the area in 1971 exceeded 70,000. Photo M-8 shows the Hot Springs Creek general recreation area.

In addition to Hot Creek there is another geothermal feature in the area used for bathing. Called "The Tubs," it consists of a small hot spring hole in the ground enclosed by concrete blocks. This area is adjacent to the Alkali Lakes.

Upstream from the Hot Creek Geysers, and within the "grandfather" area, is one of the most productive stretches of trout fishing stream in the United States. The area has been called one of the ten best stretches of fly fishing streams in the U.S. and one of the top three stretches of stream in California.

# **RECREATION USE ON THE** **MAMMOTH-CROWLEY LAKES** **AREA**

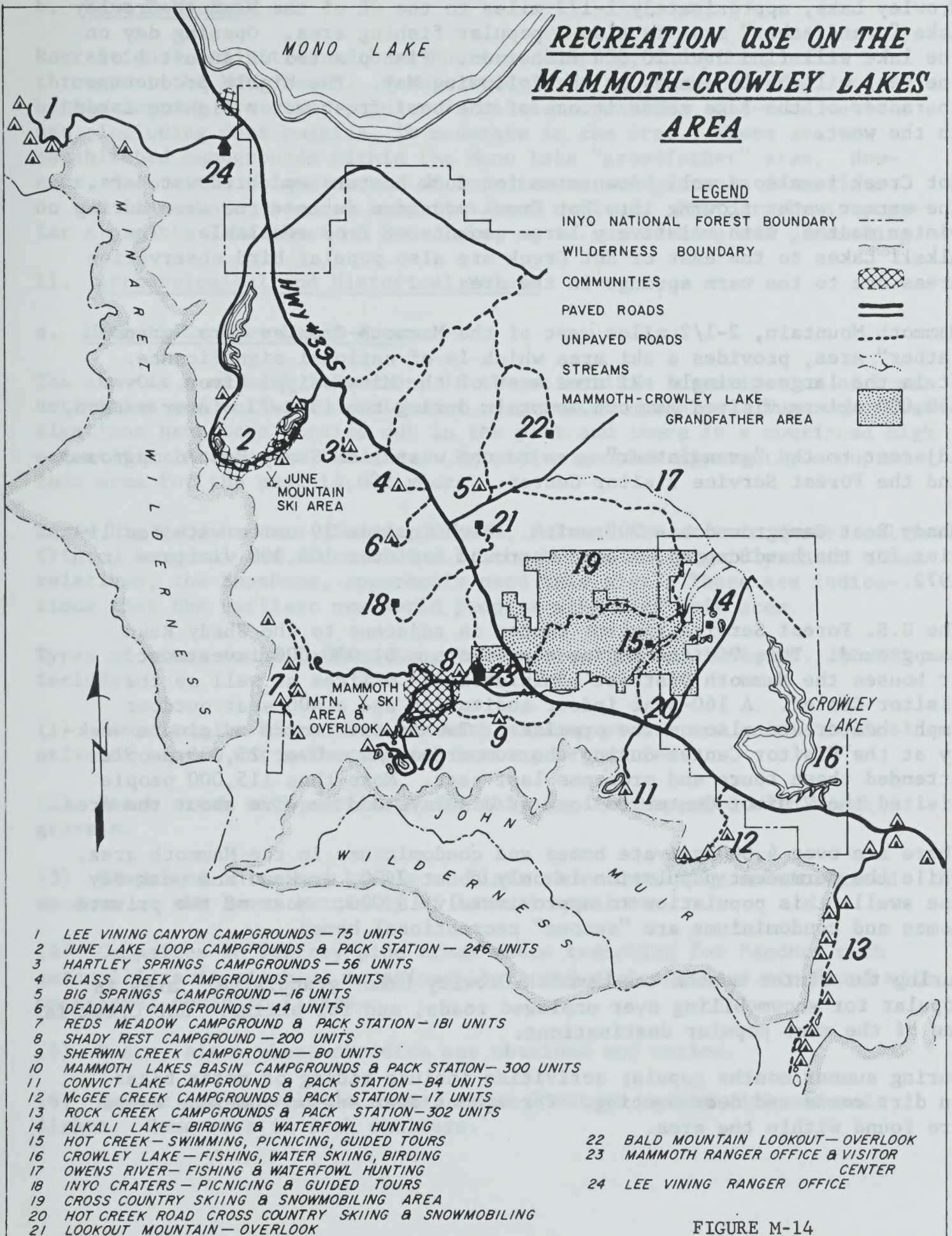


FIGURE M-14

Crowley Lake, approximately 1-1/2 miles to the SE of the Mammoth-Crowley Lake "grandfather" area is also a popular fishing area. Opening day on the lake will find over 10,000 fishermen. Fish planted on August 1 of one year will be 16 ounces by the following May. The highly productive character of the lake makes it one of the best fresh water fishing lakes in the west.

Hot Creek is also a well known area for duck hunters and bird watchers. The warmer water flowing into Hot Creek provides an ice-free area during winter months, with relatively large amounts of food available. The Alkali Lakes to the east of Hot Creek are also popular bird observation areas due to the warm springs in the area.

Mammoth Mountain, 2-1/2 miles west of the Mammoth-Crowley Lake "grandfather" area, provides a ski area which is of national significance. It is the largest single ski area west of the Mississippi River. Over 850,000 skiers visited Mammoth Mountain during the 1972-73 winter season.

Adjacent to the "grandfather" area to the west lies Shady Rest campground and the Forest Service Visitor Center.

Shady Rest Campground has 200 units, which include 19 units with facilities for the handicapped. The campground had over 100,000 visitors in 1972.

The U.S. Forest Service Visitor Center is adjacent to the Shady Rest Campground. This Visitor Center represents a \$1,000,000 investment. It houses the Mammoth District administrative offices as well as the Visitor Center. A 160-seat indoor auditorium and a 400-seat outdoor amphitheater are also on the premises. Twenty-five tours originate weekly at the Visitor Center during the summer months. Over 25,000 people attended these tours and programs last year. More than 115,000 people visited the Visitor Center to look at displays and inquire about the area.

There are over 4,000 private homes and condominiums in the Mammoth area. While the permanent population is only about 2400, weekend and peak day use swells this population to approximately 18,000. Most of the private homes and condominiums are "second" recreational homes.

During the winter months the Mammoth-Crowley Lake "grandfather" area is popular for snowmobiling over unplowed roads, and for skiing. Hot Creek is one of the most popular destinations.

During summer months popular activities include riding of motor bikes on dirt roads and deer hunting. Throughout deer season numerous camps are found within the area.

## b. Mono Lake Area

Recreational activities such as hunting, camping, and hiking exist throughout the Mono Basin. Nature study, riding, rock-hounding, and bottle hunting are other popular forms of recreation. Off-road vehicle use, including dune buggies, is moderate in the area. There are no established campgrounds within the Mono Lake "grandfather" area. However, due to the unique nature of tufa towers and pinnacle formations on the lake shore, several campsites have evolved. Photography is popular along the lake shore of Mono Lake, as is sun bathing and picnicking.

## 11. Archaeological and Historical Values

### a. Mammoth-Crowley Lakes Area

The area is a natural laboratory in the scientific investigation of human activities and cultural development of primitive peoples. Numerous investigations have been carried out in the past and there is a continued high scientific interest in the area. Primitive peoples apparently occupied this area for the past 14,000 years.

Early big game hunters (Sandia, Clovis, Folsom) the archaic desert cultures (Pinto, Amagosa) and since 1000 A.D. the Paiute and possibly their close relatives, the Shoshone, apparently used this area. There are indications that the earliest new world peoples also used this area.

Types of sites found in Mono-Long Valley area (Davis, 1964, pp. 261-62) include:

- (1) Campsites in Pinyon forests with milling stoves and points indicative of pinyon nut gathering and hunting activities.
- (2) Beach areas with artifacts and chipping interspersed with beach gravels.
- (3) Campsites on raised knolls or flats above naturally sub-irrigated meadows at the lower extremity of lateral moraines.
- (4) Campsites in Jeffrey pine areas where trenching for Pandora moth caterpillars is visible, occasional bark and slab shelters are found with occasional obsidian flakes.
- (5) Quarry sites where obsidian was obtained and worked.
- (6) Hunter and traveler's sites, about 2 meters square with man-made flakes. Some were in rock shelters.

(7) Seasonal camps near aspen groves with southern exposures on rocky benches near a good stream.

(8) Winter camps in sandy areas sheltered by dunes or draws.

Many sites appear to have been occupied a long period of time.

The density of archaeological sites as determined by surveys varies with ecological zones, but up to 7 per square mile have been reported (Davis 1964, Map 2). Relative to other Great Basin culture areas and to archaeology in the arid west in general this is a high density and indicative of the importance of the area.

Many sites have petroglyphs. One recently excavated cave with pictographs, had 3,300 visitors in 1971 on tours conducted by the Forest Service.

Rock circles, rock-walled hunting blinds and wind breaks, cleared sleeping circles, stove-lined pine nut storage rings and recent pole-and slab-covered shelters are also present in the area.

Strung out along Hot Creek from its mouth to Casa Diablo Hot Springs are a series of archaeological sites. Five of these sites have been excavated, two within the "grandfather" area, (MNO 455 & 472) one outside (Mammoth Indian Cave) and two on the edge of the "grandfather" area (Mammoth Junction site and Hot Creek Hatchery Site). Much archaeological work remains to be done, however, and present knowledge indicates that the remaining values are important as a base for future investigations.

The following archaeological sites have been recommended by the Forest Service to be listed on the National Register of Historic Places:

Mammoth Indian Caves - Partially excavated, pictographs present, used in visitor services program by Forest Service.

Casa Diablo Hot Spring Site - Area was apparently an important living area up through recent times.

Mammoth Creek Hot Springs Site - Another spring related occupation area.

There are two known sites on Little Hot Creek (Harmening, 1970).

The only site of historical importance in the area is the first Forest Service ranger station (circa 1915), located in Little Antelope Valley.

#### b. Mono Lake Area

There are no known archaeological sites in the "grandfather" areas on Mono Lake. This area has not been intensively surveyed, but it has been

reconnoitered for archaeological values. Areas where archaeological sites may be found are along the Owens Rivers, in the pinyon pine areas at Indiana Summit, on Glass Mountain, and in the Indian Meadows area.

There are no known historical sites within the "grandfather" area. The old mining town of Bodie nearby the KGRA is a state park and a National Historical Landmark; several historical sites in the following list are associated with the Bodie Complex. Those "starred" in the list are proposed for the National Register of Historic Places. A "+" sign indicates sites outside the boundaries of the KGRA, but which are close enough for potential impacts.

\*Mono Mills - Mill for mine timbers for Bodie - Ruined mill and buildings.

B & B Railroad (1881) - Bodie to Mono Mills, grade and some ties visible.

+Mono Diggings (1850's) - Early mining activity in the area. Placer mining evidence.

+Bridgeport Canyon Road - Early road in Bodie area associated with mines.

Hector Station - Site of stage station on road from Lundy to Bodie used in mining era.

Simons Spring - Historic water source southwest corner of Mono Lake.

Arcularious Ranch - Early area ranch with original building.

Cement Mine - Lost gold mine between Mono Lake and Mammoth Peak.

+\*Mammoth City - Early mining Town.

Mill City - Next to Mammoth City and an early mining town.

+\*Convict Lake - Site of 1871 capture of Nevada Prison escapees and killing of Robert Morrison, posse member.

Sawmill Meadow Mill - Early sawmill site, mortise and tenon frame still extant. Under consideration to be submitted for National Register.

+Clover Patch (1862) - Mining district associated with Benton area.

C. ENVIRONMENTAL IMPACT OF THE PROPOSED ACTION (MAMMOTH-CROWLEY LAKE AND MONO LAKE "GRANDFATHER" AREAS)

The potential environmental impacts of geothermal resource exploration and development are discussed in detail in Volume I, Chapter III, Section B of this environmental impact statement. This discussion will not be repeated here except as is appropriate to identify potential impacts as they relate to the specific environments of the Mammoth-Crowley Lake and Mono Lake "grandfather" lands and adjacent areas.

1. Resource Reconnaissance, Test Drilling, and Production Testing

Geothermal reconnaissance already has taken place in much of this area as evidenced by the "grandfather" claims. However, additional exploration may result if leases are offered for these lands. This could involve a variety of field activities such as geologic mapping; magnetic, electrical and seismic surveys; shallow drilling; etc. which could result in damage to vegetation, disturbance of archaeological values, aesthetic degradation, and other impacts as described in Volume I.

Test drilling and production testing would focus on defining geologic and reservoir characteristics and the potential for economic resource development. The actions involved are initial geophysical and geological work to define suitable areas for deep test drilling of several deep (2,000 to 4,000 feet or deeper) exploratory wells to locate the resource and define productive limits and the testing of these wells to determine the nature of the geothermal resource and production characteristics of the reservoir. Anywhere from one to six wells may be required. Photo M-9 shows an exploratory well at Mono Lake.

Drilling of each well would involve surface disturbance of 1 to 2 acres, and necessary access roads. The existing road network would be used to the extent possible. If testing is warranted, temporary test ponds of approximately 1 to 4 acres may be constructed to hold discharged waters. If prolonged testing is necessary, a separate injection well for subsurface disposal may be required.

The major potential adverse environmental impacts of these activities are from mishaps blowouts or sump breaks. The probability of such mishaps is minor (See discussions in Volume I).

a. Vegetation

Native vegetation would be disturbed or destroyed by construction of access roads, drill pads, ponds for collection of drilling mud, and other service-support facilities. Production testing of wells could vent noxious gases into the air. Contamination of the soil from spills of geothermal fluids and well drilling residues could have adverse effects on the surrounding vegetation.

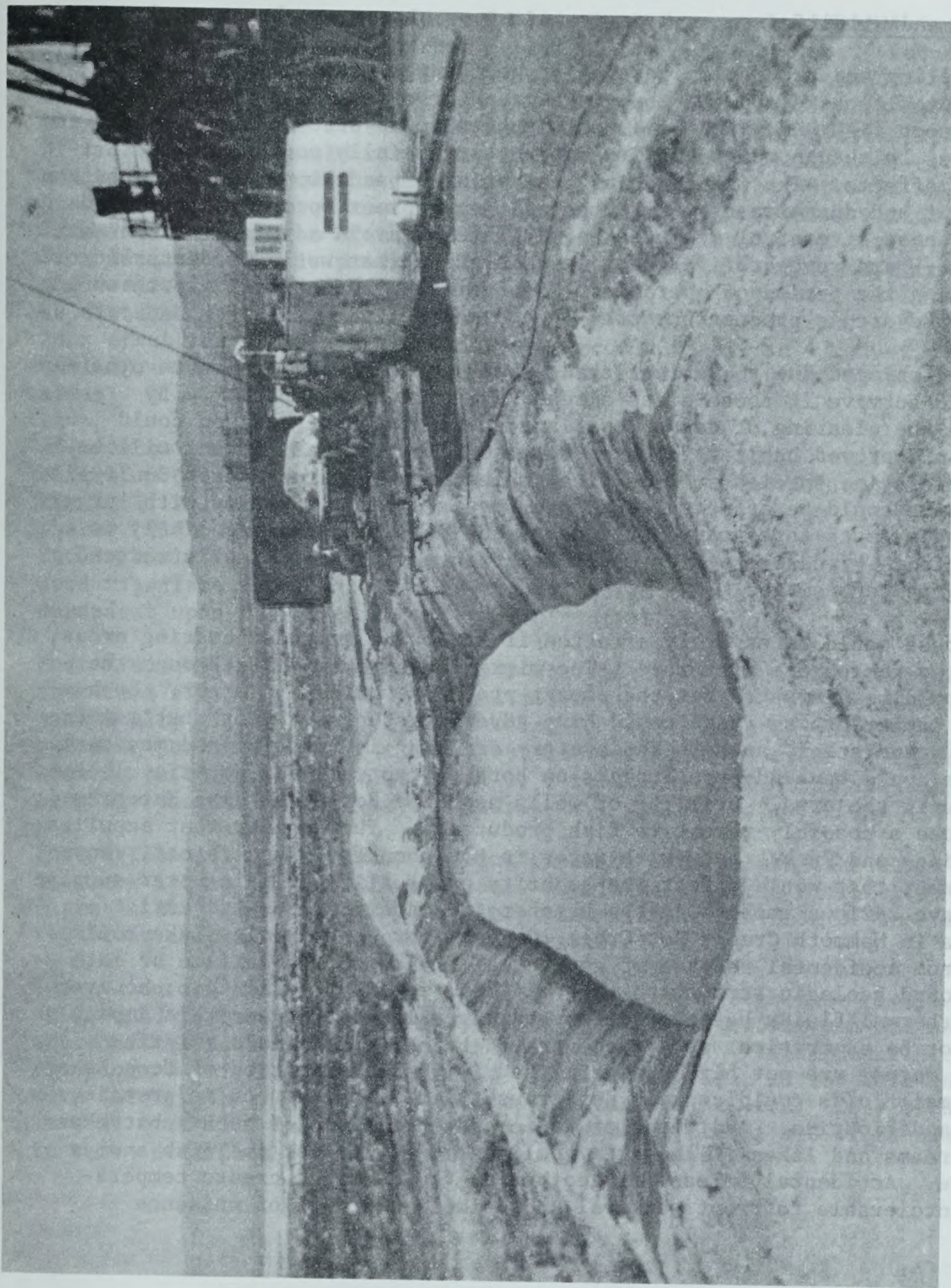


Photo M-9. Vinyl-lined mud pit at unsuccessful exploratory well at Mono Lake, California. Lining prevents infiltration to ground water and loss of fluid from drilling mud.

## b. Fish and Wildlife

Test drilling and production testing of geothermal steam resources in the Mammoth-Crowley Lake and the Mono Lake grandfather areas could have varied impacts upon fish and wildlife. Most impacts would occur on or adjacent to well sites, although water quality impacts potentially could have farther-reaching effects. The magnitude of particular impacts would depend upon the extent and duration of the geothermal development operations, and the effectiveness of control measures to mitigate or avoid adverse environmental impacts. Where revegetative cover is removed habitat would be disturbed or lost during the period of operation. Revegetation and natural growth would restore the area's production after geothermal activities have ended.

Animals displaced due to habitat changes may not be able to move to other areas and survive if these areas already are filled to capacity. By contrast the clearing of dense cover and subsequent revegetation could result in improved habitat for some species. The greatest impact will be on the microtine species such as mice, moles, and kangaroo rats. Squirrels and rabbits could be affected, but to a lesser extent. Species with larger home ranges (such as coyotes, mule deer, and bobcats) are less likely to be affected. Predator species could be affected if their prey is reduced by a significant amount.

Sage grouse could be severely affected if strutting grounds, nesting areas, and winter ranges are disturbed. The migration of mule deer through the areas could be disrouted but the impact probably would be a minor. Loss of good summer browse range could have adverse effects on deer that summer in the "grandfather" areas. Exploratory drilling in riparian and meadow habitats could have adverse impacts on both terrestrials and aquatic habitats in the area. Drilling of wells near the Hot Creek Fish Hatchery could pose a possible threat to fish production. The aquifer that supplies the springs and the hatchery with water is not completely understood. Any development that would effect the quantity and quality of this water supply could have serious impacts on the hatchery. Contamination of aquatic habitats in Mammoth Creek, Hot Creek, Owens River, and Crowley Lake could occur from accidental release of geothermal fluids on the surface or into underground geologic structures that may lead to stream drainages; however, the geothermal fluids have low dissolved minerals content and this impact would not be as critical as a concentrated brine. The area's existing surface waters are not highly mineralized (with the exception of Mono Lake). Geothermal fluids could contain dangerous trace elements such as arsenic, barium, and fluoride. Additions of toxic concentrations of such substances into streams and lakes in the area could seriously impact the fish and wildlife. Accidental release of geothermal fluids might create temperatures intolerable to trout survival and stimulate growth of nuisance algae.

The development of sump ponds could have hazardous or beneficial impacts upon fish and wildlife resources depending upon site factors. For example, if the produced water was of acceptable quality, benefits could occur in the form of increased nesting and feeding areas for waterfowl, shore and marsh birds. On the other hand, pond water containing toxic concentrations of trace elements could result in adverse effects on these birds. In addition to land modification, noise and human disturbance could have displacement effects upon certain animals and birds in the site vicinity. For example, although the effect on wildlife is not clearly understood, noise from testing wells is predicted to have a disturbing influence on courtship and nesting activities of sage grouse. Possibly a more serious effect would be disturbance by humans. The combination of noise and commotion within or near strutting grounds and nesting areas could result in a reduction of nesting, and quite possibly result in some birds moving out of historic use areas.

If erosion should result from geothermal activities there would be added siltation of aquatic habitat within the area of project influence. The threat of siltation would be most severe during development and construction phases, although some could occur during the operational stages. Siltation could result in the degradation of fish spawning habitat and production of food organisms for fish. The degree of damage to aquatic habitat would be dependent upon the adequacy of erosion control measures.

Most areas adjacent to drilling test operations, but outside of the area of immediate effects, such as physical modification and noise, could retain essentially all of their fish and wildlife populations and habitat. Where existing public access to these areas is restricted in order to reduce hazards to the public, there would be a reduction of hunting, angling, and camping opportunities on these lands.

Test drilling and production testing on lands around Mono Lake could result in minor losses of wildlife habitat. Development in the vicinity of small ponds in the "grandfather" area along the northwestern side of the lake could result in a loss of waterfowl nesting sites.

Impacts on the Mono Lake deer herd that migrates through the "grandfather" area would probably be minor unless the small corridor between the south shore of the lake and the Mono Craters was blocked by development structures. Blocking of this corridor could have an adverse effect on the deer that move through the sagebrush-bitterbrush stands of the area. Loss of habitat in this area will have effects on small mammals, birds, and predators similar to those described for the Mammoth-Crowley Lake area.

Drilling operations on Paoha Island could have significant impacts on island breeding bird populations. Human visitors to Negit Island during the gull nesting season cause excitement among both the adult and juvenile birds. This same effect probably would occur on Paoha Island due to the presence of humans; however, the breeding bird populations are much less than on Negit Island. The effects of noise from venting steam wells on Paoha Island could have some effect on the Negit Island population of gulls. Impacts on mammals on the island would be of minor significance. There are very few data on the endemic populations of mammals on Paoha and Negit Islands.

#### c. Recreation Values

The impact on recreational values should not be great during the testing phases. Additional roads may make the area more accessible to the public, although the area contains many roads at present.

Adverse impacts could result from visual and noise pollution, if drilling and testing operations are carried out near the recreational features described heretofore. The closing of areas for public safety during drilling operations would restrict public use.

#### d. Archaeological and Historical Values

Archaeological sites are most valuable to both the scientist and the sightseer when they are undisturbed. Excavations, construction or soil compaction could inadvertently destroy archaeological sites. Roads and trails for geophysical investigations and development could encounter prehistoric remains. Excavations for drill pads, camps, borrow pits, roads, etc., can do the same. Seismic blasts and the use of thumpers and vibrators close to caves, walled structures and on top of archaeological sites could cause damage. Compaction of the soil, could disturb the stratigraphy and crush artifacts within the soil.

Spills of oil, salt water, drilling mud and other liquids onto a site could contribute to further deterioration or damage to materials within the site.

Increased human activity could result in increased vandalism or disturbance of the archaeological sites in the area. Erosion processes could either remove or cover a site. Presently unknown sites could be discovered during exploratory and development operations. Such impacts could prove to be beneficial or detrimental.

#### e. Water Resources

The impact on water resources of geothermal drilling and production testing on private land in the Crowley Lake area has been minimal. Little water is used during drilling except for that required for drilling mud.

Grading for well locations and access roads would increase the potential for erosion and sediment transport, but the impact of sediment transport would be modest because land surface slopes are gentle in the valley areas where most development is expected. Rainfall and runoff are generally low. If large volumes of geothermal fluid should be released to the surface environment, they could have an adverse impact on water resources because of the relatively high trace element content of arsenic and boron in these fluids. Accidental discharge of geothermal fluids to streams or superficial ground waters tributary to Owens River would have an adverse impact on water quality of the City of Los Angeles municipal water supply.

#### f. Air Resources

Noise. Geothermal well drilling in the Crowley Lake area was accomplished with mud circulating systems. Drilling noise may, on occasion, be objectionable and special acoustical shields may be required on the drill rigs. Drilling operations generally last 30 to 45 days for each well, thereby limiting the duration of the noise source. Production testing of the wells, in which 20 to 25 percent of the fluids may be flashed to steam, generally does not exceed 90 days. Ejection of the steam fraction can be the source of objectionable noise. After testing, the wells are capped and cease to be a source of noise.

Gaseous Emissions. Only during the production testing of a well will steam be ejected to the atmosphere in large quantities. This steam essentially consists of water vapor plus non-condensable gases.

The Endogenous No. 4 well, completed in the Casa Diablo Hot Spring area, contained 0.36 percent noncondensibles by volume, was 98.25 percent carbon dioxide and 1.75 percent hydrogen sulfide. Infrared spectral analysis of the sample did not show the presence of other gases. The concentrations of noxious gases are expected to be small and are not considered harmful at this stage. As testing of the wells lasts for only relatively short periods of time, the total quantity of gaseous material emitted to the atmosphere is small. Each well is capped after testing and only a small amount of steam would be vented following the initial test release until power generation is begun. Because of frequent thermal inversions in the area as previously discussed under location and climate, release of steam and noxious gases during these periods could contribute to the build-up of air pollutants. The volume of a winter pogonip (ice-fog) in the Mono Basin to a depth of 30 meters, calculated by Mason (1971), was determined to be 25 cubic kilometers. In his analysis, it was assumed that the steam discharged in operation of a small (12.5 MW) power plant would have the same composition as steam produced at the Geysers. Under such an assumption, concentrations of  $H_2S$  could exceed California ambient air quality standards in 18 hours. The expected  $H_2S$  content of discharged steam for these areas would be considerably less than at the Geysers, but this potential still could have a significant effect upon the feasibility of operation of power plants to supply base load.

#### g. Soils and Mineral Resources

Grading of roads and well sites and construction of ponds for drilling mud and to contain hot water produced from wells during testing are the principal surface effects from geothermal testing. Erosion from construction activities could result in added siltation of aquatic habitat within the area of project influence. The siltation would be most severe during construction phases, although some could occur during the operational stages. Siltation effects could include covering of fish spawning and feeding areas and degradation of streams. The degree of siltation damage to aquatic habitat would, to a large extent, be dependent upon the success of erosion control measures.

#### h. Other Mineral Resources

The only active mine in the Mammoth-Crowley "grandfather" area is the Huntley clay pit, which is not subject to "grandfather" rights. Geothermal development adjacent to the clay deposit would have little or no adverse impact. A beneficial impact could result if roads into the area are up-graded as a result of geothermal development. There are no known deposits of block pumice subject to mining location in the area. Other forms of pumice, decorative stone, and sand and gravel are salable under the material sale act of 1947. If the area develops into a viable geothermal power source, material sales would probably be subordinate to the geothermal resource.

Development of the geothermal resources adjacent to North Crater in the Mono Lake "grandfather" area would have little if any impact on the pumice claims. The crater itself would not be suitable drilling or plant site, and access to the crater can be maintained without impairing development of the geothermal resource. No significant impact is anticipated for the cinder pit on Black Point. The pit occupies only a small area and can continue to operate without interfering with geothermal development.

#### i. Land Use

As previously stated, 50% of the Mammoth-Crowley Lake "grandfather" area contains timber. Timber harvesting has been conducted in the past and is planned for the future. Impacts on timber resources during the testing stages probably would not be great. Impacts would consist primarily of removal of portions of timber for road and test site construction, plus an areas around each drill site where logging would not be allowed. Upon development, the areas around drill sites probably would be removed from allowable cut calculations until geothermal activities end. If, development does not occur the area would continue to be available for timber production.

The effects upon grazing and other land uses would not be significant until the field development and plant construction phases.

## j. Projected Development

In the event exploration and developing testing do not result in commercially producible resources under existing technologic and economic conditions the area involved would not be further developed, at least until such time as economic production would be possible. In such instance, the environmental impacts associated with production would either be delayed for several years or would not occur if production is not undertaken.

## 2. Field Development, Power Plant and Powerline Construction, Energy Generation and By-Product Facilities

Production-scale development of the geothermal resource would result in increased operations and in potential environmental impacts. Some activities, such as drilling and testing, would continue for many years. Additional wells would be required for development of the resource, pipelines would be required to convey the hot water or steam from the point of production to the power plant, power plants would be built to generate electricity, and powerlines would be needed to transmit the energy to existing mainlines or to the point of use.

It is expected that the resource will be of the hot water type. For electrical power generation, one or more of several general systems might be employed. Steam turbines utilizing flashed steam may be used, (as at Wairakei, New Zealand, and Cerro Prieto, Mexico) or a binary closed system (described in the general statement). Other systems such as the helical screw might be utilized should further research and development work prove successful. Both the flashed steam and binary systems involve essentially the same impacts of well and plant equipment; the major difference between the two is that the binary is a "closed" system, the water being completely contained (no exposure to air) from production through injection. Each system would involve essentially the same number of wells, hot water and injection piping, and size of generating building and cooling towers.

Development in this area probably would be by 50 to 100 mw increments, similar generally to The Geysers. Generally, it will require about one section of land per plant (640 acres). A typical unit might be a generating plant and cooling tower occupying 3 to 5 acres, and 20 to 25 wells each occupying 2 acres initially but reduced to about 50' X 100' after completion. There also would be temporary and permanent access roads. Based on a comparison of aerial photos before and after development for a typical Geysers plant, about 13 percent of the total land area supporting a generating plant is lost to permanent site occupation. Considerably less will be needed for the Mono-Mammoth area since the topography is much gentler, and less cut and fill work will be required. For this area it is estimated that a 5-10% permanent land loss could be expected.

A space heating system, if feasible and economically justifiable, would involve piping of hot fluids from wells or plants to the inhabited areas, then a distribution and waste collection system similar to the water and sewage systems but special treatment or reinjection might be required for geothermal fluids.

Potential environmental impacts of development are discussed in the following sections.

a. Vegetation

(1) Mammoth-Crowley Area

Production-scale development of the geothermal field could result in minor to major alteration of vegetation. The removal of vegetative cover for roads, well pads, collection and storage ponds, power plants, steam transportation lines, cooling towers, reinjection lines and wells could have a major impact on the vegetative community. A power generating plant of 100MW with approximately 20 wells, and ancillary supporting facilities, on one square mile of land (640 acres) could result in removal of 5 to 15 percent (30 to 100 acres) of the vegetative cover on the land area. Some of this impact can be mitigated through reseedling of the disturbed sites; however, construction of roads, parking lots, power plants, cooling towers, and other permanent structures will take some portion of the land out of production from a vegetative standpoint. Such impacts could vary widely depending upon local vegetation conditions.

The effects of gaseous emissions from venting wells and cooling towers may affect the surrounding vegetation. Some of the non-condensable gases may harm vegetative growth. An increase in humidity from cooling tower emissions could alter the vegetative patterns on a local basis. The long-term effects of development of a 1,000 MW system could have a significant effect on the native vegetative communities in the immediate area.

(2) Mono Lake Area

Development of the geothermal resources in the Mono Lake "grandfather" area would have similar effects on vegetation as in the Mammoth-Crowley Lake area, but the impacts would be confined more to the shrub and grass communities. Those plants displaced would be lost to the ecosystem. Shore bird habitat could be lost if lakeside riparian areas were disturbed by development. Recovery rates for disturbed areas would be slow because of the semi-arid conditions.

b. Fish and Wildlife

(1) Mammoth-Crowley Lake Area

Development of the geothermal resources could have major impact on the fish and wildlife resources in the area. The impacts described for the exploratory drilling phase could be magnified. Loss of habitat, due to disturbance of vegetation, may result in local changes in species density and composition. Predator-prey relationships may be disrupted and food chains and food webs altered in the ecosystem. Loss of habitat also may result from indirect effects, such as noise and human disturbance.

Disturbance to sage grouse during the breeding and nesting seasons could result in a decrease in the population. Traditional deer migration routes could be blocked by pipelines and roads, and portions of the key summer browse stands could become unsuitable for deer use due to disturbance and developments.

Introduction of pollutants into the aquatic habitat systems of Hot Creek, Mammoth Creek, Owens River, Little Hot Creek, and Crowley Lake, through accidental spills of geothermal fluids, could have major impact. Reinjection of mineralized geothermal fluids if not properly accomplished, could cause pollution of the aquifers that charge the various aquatic systems in the area. Changes in water quality and thermal balances in these systems, could result in major impacts to the terrestrial and aquatic organisms that depend on the system for their survival.

Perhaps the most significant potential impact of geothermal production on wildlife may be lowering of the thermal water table in the Hot Creek area, with resulting drying up of the springs. (Photo M-10) Many flowing springs and geysers once present in Geyser Valley, just north of Wairakei in New Zealand, have progressively dried up as production took place at Wairakei. At present, Geyser Valley has nothing but steam vents and superficial acid-sulfate springs. A similar occurrence at Hot Creek could result from extensive geothermal development.

The effects of increased humidity, due to discharge of water vapors from cooling towers, are little understood. Inversion layers may result in increased fog banks in the Mono Long Valley area. Long-term release of water vapor into the area may affect the winter temperatures in the basin, resulting in a reduction in winter temperatures that could make the area less suited for use by waterfowl and shore birds during the winter season.

Additional power distribution lines located in flyways or over nesting and feeding sites could cause some mortality of waterfowl, raptors, and other birds from collision or electrocution; however, the impact should be no greater than that from existing power transmission lines for other energy sources and new designs are being studied to further mitigate this hazard.

Full development of the geothermal field could result in land subsidence and seismic activity in the area. This possibly could result in changes in thermal springs in the stream drainages or cause stream channel changes which would alter aquatic habitats.

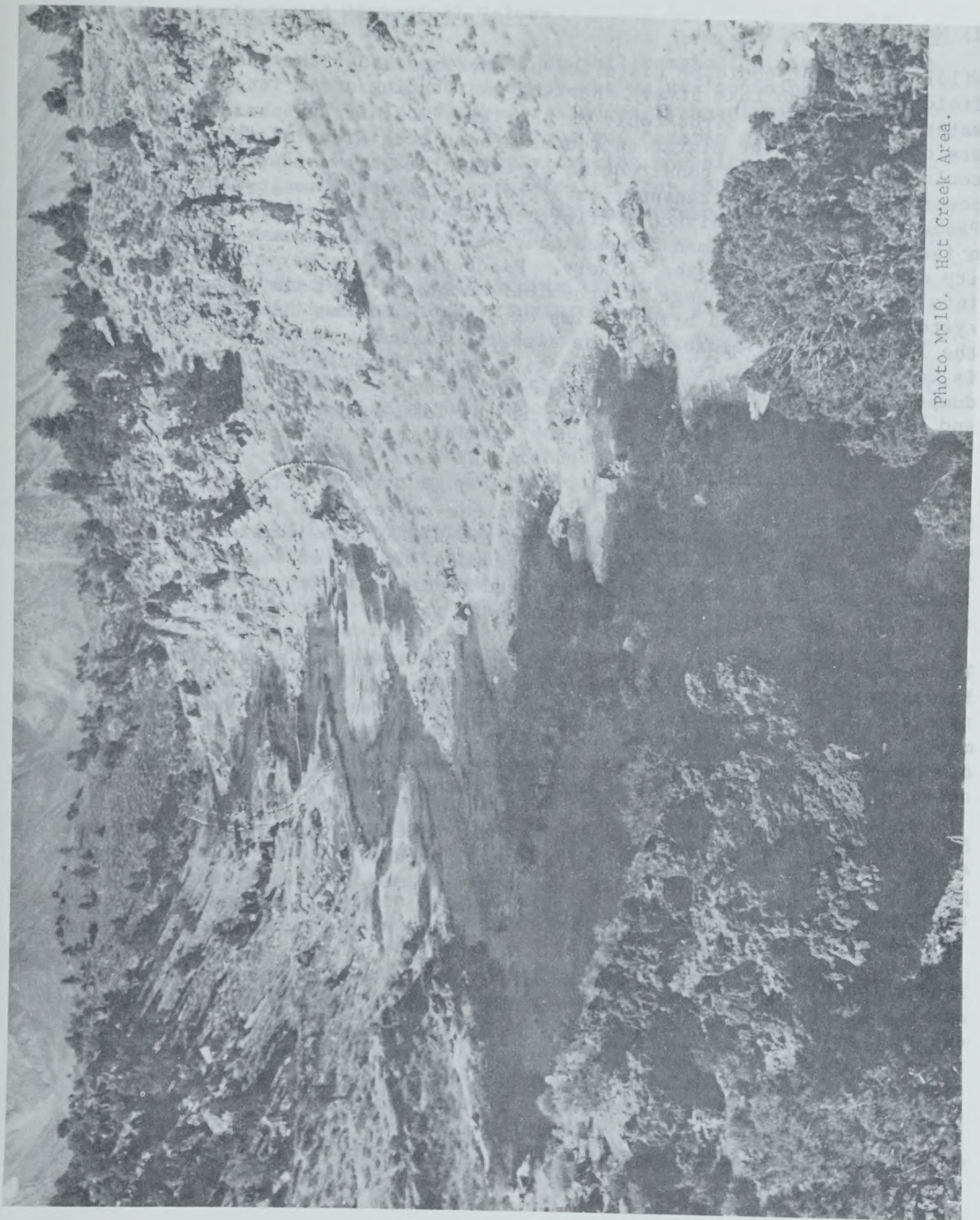


Photo N-10. Hot Creek Area.

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## (2) Mono Lake

Wildlife habitat could be disturbed by development of the geothermal field in the Mono Lake area. Nesting and feeding areas for waterfowl and shore birds could be partially lost if lakeshore areas are developed. Deer migration routes around both sides of the lake could be disrupted by construction of facilities for conduction of steam, power generation and transport, and cooling towers. Development on Paoha Island could indirectly affect the Negit Island gull rookery by noise pollution and human disturbance, resulting in lowered productivity or in desertion of the rookery. Discharge of geothermal fluids into the lake could change the chemical composition of the aquatic system and destroy the brine shrimp or other organisms that live in the lake; however, because of the size and salinity of the lake, this is very unlikely unless huge quantities of geothermal fluids were dumped into Mono Lake. Food sources for birds, such as brine shrimp and black fly larvae, could be lost if the lake ecosystem is altered.

### c. Recreational Values

The Mammoth and Mono Lake areas have unique recreational settings. They are located approximately 5 hours from the Los Angeles complex, and the area has become one of the major playgrounds for all of Southern California. Due to this high use, the need to minimize impacts and protect the recreation resources and environmental values is great.

The aesthetic and undisturbed qualities of an area play a large role in determining the quality of hunting and fishing. Any development that detracts from natural scenic or area use values could have a detrimental impact on recreational activities. Since the economic base of Mono County has shifted from mining and minerals to outdoor recreation, this impact could be of economic significance to Mono County.

An overlook atop Conway Summit provides an excellent view of Mono Lake and surrounding country. Geothermal developments, such as pipelines, power plants, powerlines, roads, and steam plumes, would be visible and could detract from scenic values. However, to some these would be man-made features of interest.

Production development of a geothermal field in an outdoor recreation and scenic-aesthetic environment could have major visual impact on the existing asymmetric landscape with the development of many wells, new roads, pipelines from wells to points of use, construction of power plants and transmission lines, byproduct extraction plants, and facilities for storage and reinjection of spent brines. New access roads could contribute to improved recreation access or to recreation management problems of vandalism, littering, off-road vehicle use, and higher density use.

#### d. Archaeological and Historical Values

Any type of excavation, earth movement or soil compaction, in and about historical places, will reduce or destroy the values contained in the site. Many historic sites should be treated as archaeological sites. Caustic and hydrocarbon liquids, odiferous and caustic gases, could all have an effect on historic sites, affecting the site and its structures. Increased vandalism to historic sites could be an important factor in connection with exploratory and development stages of the geothermal resource.

Heavy equipment could cut up old historic trails. Thumpers, vibrators and explosives used near historic structures could temporarily damage the historic scene.

Oil, caustic and odiferous liquids and gases, spoil not only the visible historic scene and atmosphere, but under some conditions can cause deterioration of structures. Painted wood structures, metal objects and other historic things could be affected by caustic materials as the result of spills, blowouts, or other mishaps.

The site of the old Ranger Station in the Mammoth-Crowley Lake "grandfather" area is the most significant historic value. Any earth-moving activities, on or near the site, could damage this structure.

Any of the historical areas in the KGRA and the surrounding area could be impacted, including those areas on the proposed National Register of Historic Places sites, and those associated with Bodie and the Mono Lake Mining Area.

#### e. Water Resources

The potential impact of development upon water resources generally would be in proportion to the scale of activity. The principal hazard would be from accidental release of geothermal fluids to surface waters or shallow ground waters, and from increased sediment production. There could be risk from accidental releases from waste-water pipelines, and from geothermal fluid storage ponds. Minor leakage would not pose a serious threat to water resources in the Mono Basin because the ground water already is too saline for most uses; but, a leakage for long periods could cause environmental damage to Mono Lake. Elsewhere in the area, substantial leakage could pose serious water pollution problems.

The impact of geothermal steam development on surface streams would be mainly in the form of temporarily increased sediment yields, stemming from clearing operations. Additional areas would be affected as more roads and well sites are constructed. Although expansion of new producing areas may result in increased sediment loads, the loads from older producing areas would be progressively reduced as erosion-control measures and revegetation take effect.

Development will require disposal of liquid waste from the power plants. A portion of the geothermal fluid is consumed for condenser cooling in electrical generation. At the Geysers, 80 percent of the steam is used in this way and 20 percent of the original water content must be disposed of, together with its dissolved minerals. However, in a hot water system, such as in the Imperial Valley area or the Mono Lake-Long Valley area where steam may form 25 percent or less of the fluid production, a greater amount of waste water will have to be disposed of--perhaps as much as 90 percent of the original production. Two possibilities appear feasible for such disposal in the Mono Lake-Long Valley area; (1) reinjection into the producing zone, or (2) discharge to Mono Lake. If discharge to Mono Lake proves feasible under the State of California Water Quality Standards, this may be a desirable alternative as it could help to maintain the lake level. Since Mono Lake has no outflow, the Lake will inevitably increase in salinity from natural processes so a certain amount of degradation from geothermal fluids might not be adverse over time.

#### f. Air Resources

During field development, noise will be associated with well drilling, venting of wells, construction of power plants and byproduct facilities, operation of cooling towers. The potential for loud noise also exists if steam lines or well head equipment should fail. These sources of noise can have a significant impact on wildlife, on surrounding land uses, on the aesthetic qualities of the area, and may pose a health and safety hazard to employees.

Non-condensable gases, such as hydrogen sulfide, carbon dioxide, ammonia, and mercury vapor may be associated with steam from geothermal wells in the area. These gases are concentrated at the power plant during condensation of the steam, and are generally ejected to the atmosphere. Water vapor is vented from the cooling towers to the atmosphere. These vapors and gases may contribute to fogging, which frequently occurs naturally during winter months, and could lead to buildup of noxious gases in the atmosphere, which could pose a health and safety hazard to residents. Various gases may be generated in a byproduct recovery plant. Release of such gases should increase the potential for air pollution problems in the basin.

#### g. Soils and Mineral Resources

Soil erosion could be more significant during the construction period leading to the operational phase due to increased road and site development. The Department of Water and Power, City of Los Angeles, is especially concerned about any potential siltation source and effect on Crowley Lake, since this is an important reservoir in the water supply system of the City. The degree of siltation damage would be dependent upon the success of erosion control measures. The impacts upon mineral resources would be essentially the same as those resulting from test operations.

#### h. Land Use

In the Mono Lake-Crowley Lake area, the increases impact from full-scale development would result from drilling of numerous wells, construction of pipelines from the wells to points of use, construction of power plants and transmission lines, facilities for reinjection of geothermal fluids and possibly fluids from byproduct plants.

The engineering problem of heat loss from the fluid in transit would be similar to that of the Geysers field, which requires small power plants close to the wells with insulated surface piping. The geothermal development at Cerro Prieto, Mexico, which is a hot water-dominated system, can perhaps serve as a model of the type of power plant development to be expected in the Mono Lake-Long Valley area. At Cerro Prieto, some 15 producing wells, distributed over an area of about 1 square mile, supply steam to a 75 MW plant at a maximum distance of 1 mile. The fluid produced by the wells there consists of about 25 percent steam and 75 percent water. A centrifugal-type separator at each well separates the fluid, and the steam is conducted to the power plant in 12 34-inch insulated, above-ground, pipelines. The operation is similar in scale and methodology to any one of the plants at the Geysers field, except for the feature of water separation. At Cerro Prieto, the wastewater is disposed of by surface discharge. (Additional detail is included in Volume I and in the Imperial Valley section of this volume).

Assuming a similar pattern of development to that of Cerro Prieto, one could expect development of several centers of power generation, each with a power plant and network of radiating pipelines to wells. In addition, a pipeline system would be required to collect waste water from the producing wells and to convey it to reinjection wells located strategically throughout the field. Such surface modifications would represent a change in land use, but not necessarily a severe environmental impact.

The impact on grazing of full-scale development and production may result in some long-term reduction in carrying capacity and obstruction in traditional patterns of movement in grazing areas. Therefore, a lesser number of animals will be supported by available forage.

If the geothermal resource is developed, additional acres of commercial sawtimber would be removed from the management base; thus, reducing the annual allowable cut. Developments such as power transmission lines, steam lines, waste ponds and generating plants would physically remove timber. While such timber could be salvaged at the time of removal, the site would not be subject to further timber production until after geothermal operations were completed. In addition to the timber actually cut, there could be adjoining areas around and within the developed area that still would maintain a timber stand but the timber might not be accessible for timber production. Where such areas involve mature timber, some would be lost due to natural mortality during the 25 to 50 or more years of geothermal operations.

### 3. Non-electrical Energy Development

#### a. Space Heating

Wintertime heating of public and private housing and buildings in the Mammoth area is very costly due to low average temperature, the necessity for continuous winter heating to keep interior pipes from freezing, and the high cost of electricity, liquid propane or butane fuel. There is a good possibility that space heating could be accomplished by use of hot geothermal fluids at greatly reduced costs, thus resulting in a significant beneficial impact to the community.

Space heating using naturally occurring hot water is being accomplished in several areas throughout the world and the U.S., and is the primary usage of the geothermal resource in some areas. The hot water is from on-site wells, or is brought in from outside sources.

In the Mammoth area, the hot water could be obtained directly from wells, or from generating plant down-stream waste water. Such plant waters, after flowing through all heat exchangers, still are at approximately 180°F, which would be sufficient for space heating. Widespread use would require a public utility type system, similar in principal and scope to the existing fresh water system. Hot water would enter a building, run through either radiators, forced-air heat exchangers, or radiant heat piping, then be rejected to either the a sewer or a separate waste system for appropriate treatment and disposal.

A potential additional beneficial use of a hot water system could be to melt snow from key roads, intersections, or parking lots. This could facilitate traffic movement and increase safety during the periods of heavy skiing weekend traffic. Snow removal costs might be significantly reduced, and unsightly and inconvenient mounds and ridges of snow would be eliminated.

While the potential for space heating is great, it may not be feasible from the engineering and economic standpoint. Some of the problems would be heat loss if hot water had to be transported over long distances, the economics of establishing the distribution system, and disposal of waste geothermal water.

The environmental impact of establishing a hot water system for space heating and road snow melting probably would be minor as compared to power generation, in that existing wells might be used, no cooling towers or plants would be required, and piping systems would be of smaller diameter and less extensive. Inasmuch as system temperatures would probably be lower (150-250°F v. 350-450°F), temperature differences between start-up and use would be lower; consequently, expansion problems would be less severe, and buried pipelines might thus be feasible.

The impact during development and construction phases would be similar to power development. After a system is established, the net overall visual impact would be minor, even if new wells closer to the Mammoth townsite were required. Probably only a few wells (2-8) would be involved. (One shallow well in Rotarua, New Zealand, supplies enough hot water to heat two large 3-story Government buildings). If pipelines could be buried, the net disturbance would be small areas (less than one acre) around wellsites, and necessary access roads.

#### b. Sewage Plant Effluent Disposal

It is understood that some problems now exist with disposal of the effluent water from the Mammoth sewage treatment plant such problems will increase with further development and use in the area. It has been suggested that the sewage effluent be injected into subsurface formations along with geothermal waste water, using one or more of the wells which would be drilled specifically for injection disposal purposes. This might prove to be an ideal solution to a difficult problem; treated sewage waters would be of a higher quality than those of the subsurface formations being used for geothermal water disposal; additional sterilization would occur since injection wells would have bottom-hole temperatures of 200-300°F or higher.

The undersirable environmental impact of such a system would be minimal since only a few buried pipelines would be needed. The potential beneficial impacts probably would outweigh any negative impacts. As with other types of utilization of the geothermal resource, the feasibility of sewage effluent disposal would depend on solving the technical problems and would have to be economically justifiable.

#### c. Demineralized Water

The Mammoth area water supply has in some past occasions been critical. Further development in the area would require additional supplies from the already limited sources. It is possible that some form of desalination of the produced geothermal waters might be justifiable. Two such processes are currently being investigated by the U.S. Bureau of Reclamation in the Imperial Valley, California. The water downstream of the generating plants could have sufficient heat (approximately 180°F) content for use in this type of plant.

Fresh water production from geothermal sources would involve plant construction at existing generating facilities, and a pipeline to the utility system distribution station. The net additional environmental disturbance would thus be minimal.

As with space heating, the by-product development of demineralized water would probably result in an overall favorable impact for the area.

#### 4. Subsidence and Seismic Impacts

The extraction of fluids from a ground water reservoir, where withdrawals exceed the recharge rate and reservoir pressure declines, may cause land subsidence. In most of the undeveloped area, ground subsidence would have little adverse impact and may be tolerable. Locally, subsidence may be serious for developed areas such as resorts. Most parameters for predicting subsidence, such as anticipated pressure decline, thickness and compressibility of the water-bearing deposits, and lateral extension of fault blocks, are not well-known in the Mono Long Valley area.

Another potential environmental impact is increased seismicity that could be induced by geothermal development. The Mono Lake-Long Valley area is known to be faulted and seismically active. There are indications that increases seismic activity, in the form of swarms of micro-earthquakes, has occurred in other areas as a result of fluid injection into confined systems. Similarly, heavy production of fluids from confined systems, which sometimes causes land subsidence, has been related to tectonic activity, such as displacement of fault surfaces as the confined system readjusts to changing stress.

The potential consequence of triggering a moderate earthquake during geothermal production involves possible damage to nearby structures including the power plant, steam pipes, etc., and rupture of producing wells resulting in a blowout. Also, damage to the power plant and rupture of steam pipes, due to intense shaking, could result from a naturally occurring earthquake.

## 5. Social and Economic Effects

Local spending by temporary construction workers and drilling crews would contribute to the local economy; however, it is not expected that permanent employment or employee spending would be large enough to have much impact due to the small number of employees required for exploration, development and full-scale power production or by-product recovery.

Should a geothermal resource be discovered, developed and utilized in the Mono-Long Valley area, it could be expected to contribute tax monies to both State and county Governments.

Development and plant costs involve considerable sums of money. Overall well and plant costs per megawatt of power developed could be expected to be similar to The Geysers; therefore, Mono County mineral and property taxes could be roughly equivalent. Sonoma County geothermal tax revenues for fiscal 1973-74 are expected to about \$1 million or about \$2,500 per megawatt of power production capacity.

Assuming similar assessment treatment and tax rates and that tax treatment and returns would be essentially the same whether the lease land be private, State or Federal ownership, full development of the estimated resource capacity of 750 mw for the Mono Lake area could result in tax revenues in the order of \$1.9 million per year. Similarly, full development of the estimated 1,000 mw resource capacity for the Mammoth-Crowley Lake area (Long Valley) could result in tax revenues of \$2.5 million per year. Total tax potential for the two areas under such assumptions could be over \$4 million with full development of the estimated KGRA resource potential.

Potential royalty payments to the Federal Government likewise could be significant. If it is assumed that the geothermal resources gross income to the producer is similar to the 2.65 mils per kilowatt hour rate as at the Geysers, the development of 750 mw of capacity at Mono Lake could produce \$1.6 million of royalty income per year. Similarly, the Mammoth-Crowley Lake area 1,000 mw potential could represent annual royalty income of \$2.1 million.

Development of by-product uses of the geothermal resource, such as space heating and water desalination systems, likewise could result in State, county, and Federal tax and royalty income, but in lesser amounts. Extraction of chemical by-products would not be anticipated if the geothermal waters proved to be of relatively low mineral content as from existing wells at Casa Diablo.

## 6. Population and Employment

Geothermal development could have a minor to major impact on the population and business structure of local communities, depending upon the size of the development, and proximity and size of the community. A development of even one 100 mw plant at Mono Lake could be significant, since the only nearby town is Lee Vining with a population of 400. Full scale development of 500- 1000 mw power at the Mammoth-Crowley Lake area could also be a significant social impact on the community of Mammoth, which had a permanent year-round 1972 population of 2,886 with a full time employment base of approximately 1400. (Monoplan Report, Part 4)

Development of a major geothermal resource of 1,000 mw in the Mono-Long Valley area probably would parallel that experienced at The Geysers steam field, i.e. a cautious, orderly step-by-step development with construction of 1 to 2 plants per year over a 5 to 10 year period. In all probability, it would take 3 to 5 years after leases were issued before the first plant was put into operation. Employment during the full-scale development period would average 150 to 300 people, with the biggest percentage involved in new well drilling and plant construction. These operations would be year-round, resulting in rather steady summer-winter employment, rather than seasonal. Upon full development, employment might stabilize at approximately 200 to 300 people. Such a population increase would have a major impact on the Mono Lake Population and economic structure, and lesser impact on the town of Mammoth.

As discussed previously under Land Use, the Mammoth economy is about 75% recreational oriented, subject to wide changes in type of summer-winter employment, and is sensitive to the general status of the State's economy. Geothermal development could add a significant steadying influence to the local economy. Adjusting housing to the increased population should not be too difficult since the increases would occur gradually over a period of several years until full-scale development was initiated. Providing sufficient schools for the additional families might be a short-term problem, but, over the long run, should create no serious problem; the geothermal industry is highly capital-intensive, resulting in a very high net assessed valuation per geothermal employee, i.e. the industry probably would contribute much more in taxes than it would require in tax support for employees.

## 7. Transportation

The existing road network should be ample to take care of the drilling and construction equipment which would have to be moved into the area. In some cases, existing access roads could deteriorate under heavy equipment usage and would have to be improved to handle such usage.

## 8. Mishaps

The principal forms of accidental environmental impact likely to be encountered in drilling and production testing in the Mono Lake-Crowley Lake area are uncontrolled flows of fluid, spills of geothermal brines, brush and forest fires. In any exploratory drilling in an untested area, there is a possibility of such flows of steam, water, or gases such as hydrogen sulfide, carbon dioxide, and hydrocarbons.

There is the possibility of accidental releases of low quality mineralized fluids, through failure of levees enclosing storage ponds or through pipeline leakage. These are continuing potential hazards that can be minimized through careful supervision and maintenance. Such accidental releases probably would not pose a serious hazard in the Mono Basin because Mono Lake is highly saline, and small additional quantities of less saline geothermal waters would not have a significant impact. However, elsewhere in the Mono Lake-Crowley Lake area, release of poor quality water could seriously damage water resources.

The brush and forest fire hazard is not peculiar to geothermal development as all human uses of the area can pose fire risks. However, it could be increased due to the greater level and type of activity and traffic associated with development. The brush fire hazard would be modest in the Mono Basin because of sparse vegetation, but in the forested regions in the area, particularly during the dry season, disastrous brush and forest fires could occur with their associated effect upon the environment.

The potential for impact from blowouts and accidental spills of geothermal fluids is discussed in detail in the general statement. Other principal environmental impacts that could occur in the Mono Lake-Long Valley area are land subsidence and induced seismic activity.

#### D. MITIGATING MEASURES INCLUDED IN THE PROPOSED ACTION

A detailed discussion of mitigating measures is included in Volume I, Chapter III, Section C of this impact statement. Such information will not be repeated here except to the extent further description is necessary relative to the specific areas involved.

Mitigation of the potential adverse environmental impacts of development of Federal geothermal resources in the Mono Lake and Mammoth-Crowley Lake areas will be accomplished through enforcement of applicable Federal laws and regulations, appropriate State laws, and lease and land-use permit stipulations. Appropriate use also will be made of local government regulations.

The potential adverse impacts of proposed development of Federal geothermal resources in the Mono-Long Valley area can be mitigated to acceptable levels by proper advance planning and application and enforcement of the geothermal regulations, lease and permit stipulations, and GRO orders. This would apply to all stages of operations--reconnaissance exploration through to final project abandonment. The regulations are sufficiently broad in scope to enable necessary controls for environmental, operational, and conservation problems which may arise. The surface land management agency and the lease supervisory agency will be able to eliminate or control occurrences and potential adverse impacts such as blowouts, seismicity, subsidence, archaeological and historic damage, erosion and siltation, surface and subsurface water pollution, objectionable noise, and significant disturbance to fish and wildlife. If problems develop which cannot be satisfactorily solved, the regulations provide for shutdown of operations until such time as acceptable corrective action is taken.

Under provisions of the geothermal regulations, operational and environmental controls may be augmented or stated in greater specific detail through use of any or all of the following different methods: (a) Geothermal Resource Operational (GRO) Orders issued by the Supervisor, U.S. Geological Survey (30 CFR 270.11); (b) the Plan of Operations (surface oriented) as approved by the Supervisor and appropriate land management agency (30 CFR 270.34); (c) applications for permits to drill new wells or perform remedial work (subsurface oriented), approved by the Supervisor (30 CFR 270.71). Specific oral or written instructions from the Supervisor (U.S. Geological Survey) will include appropriate coordination with the surface land management agency (Bureau of Land Management, Forest Service, etc.). All of the regulatory procedures as set forth in the leasing and operating regulations, lease and permit stipulations, and GRO orders are binding on the lessee. Local ordinances will be implemented as appropriate through one of the above regulatory procedures. (The general provisions of the applicable laws and regulations are described in considerable detail in Chapter III of the general statement.)

If a significant geothermal resource is discovered in the area, i.e., one involving two or more power-generating plants, it is probable that development

would occur over a period of years for technical, economic, and environmental reasons. This probable prolonged development period (The Geysers steam field may require 20 years of full development) of itself would tend to be a mitigating measure in that problems discovered in initial operations may be solved and taken care of in succeeding operations.

### 1. Geothermal and Geophysical Exploration

Section 3209.2 of the proposed regulations provides that no exploration operations will be conducted on public lands except pursuant to the terms of a Notice of Intent which has been approved by the authorized officer. Section 3209.1-1 sets forth the requirements for filing such a Notice. Special provisions relative to the particular area involved will be included as appropriate to assure adequate environmental protection in connection with such exploratory operations. (For additional detail and a sample form, see Volume I, Chapter III, Section C, Exploration Operations.)

### 2. Environmental Assessments

This section of the environmental impact statement primarily covers the "grandfather" areas of the Mono-Long Valley KGRA. Leasing of other areas within the KGRA will be subject to the provisions of Section 3200.0-6 of the proposed regulations which prescribe the preleasing procedures to be used for proposed geothermal leasing. When an area is initially considered for leasing, or when the need arises, interested bureaus and Federal agencies will be requested to prepare reports describing, to the extent known, resources contained within the general area and the potential effect of geothermal resources operations upon the resources of the area and its total environment. Prior to final selection of tracts for leasing there will be a full evaluation of the potential effect of the leasing program on the total environment and its resources. If such an evaluation indicates that the issuance of leases would be a major Federal action significantly affecting the environment, and that such potential impacts are significantly different from those described herein for the "grandfather" and adjacent areas, no leases would be issued unless a supplemental environmental statement has been issued under Section 102(2)(C) of the National Environmental Policy Act of 1969.

The Director shall develop special terms and conditions to be included in leases when they are needed to protect the environment, to permit use of the land for other purposes, and to protect other natural resources. Such terms and conditions will be specifically designed for each area to assure that environmental impacts are avoided or minimized and held to acceptable levels.

### 3. Monitoring

Monitoring will be conducted for all potential impacts related to exploration development, and production of geothermal resources. Such impacts include

noise, air quality, water quality, erosion, fish and wildlife, seismicity, and land subsidence. Monitoring may take the form of continuous recording of parameters, periodic sampling, or aerial survey at intervals.

The extent and frequency of monitoring activities may differ from place to place within the Mono-Long Valley KGRA owing to natural variability of geology, terrain, biological factors, climate, geothermal fluid and gaseous characteristics, water quality, etc. Therefore, appropriate measures to monitor environmental impacts will be determined on a case-by-case basis for each lease.

Noise and air quality impacts and, to a lesser degree, water quality impacts can be identified with specific operations and the lessee will be required, by lease stipulations or GRO orders, to provide such monitoring as is deemed appropriate. Water quality and sediment transport as related to an entire drainage area normally would have to be the responsibility of the appropriate public agencies.

Similarly, land subsidence and seismic monitoring pertain to operations throughout the producing area and normally would be a responsibility of public agencies. Presently, there are no Federal programs for seismic or subsidence monitoring in the Mono Lake-Long Valley KGRA. If geothermal leasing of Federal lands does take place, it is anticipated that both seismic and subsidence monitoring networks would be established, probably by the Federal Government. State or Federal monitoring of water quality would be instituted as necessary if geothermal development occurs.

The operating regulations provide authority for the Supervisor to act promptly to effect control over such immediate problems as blowouts and fires. Less immediate effects such as land subsidence, increasing seismicity, and surface instability will be controlled under specific written orders or instructions from the U.S. Geological Survey. A detailed discussion of mitigating blowouts and other mishaps is included in Volume I, Chapter II, Section C of the general statement.

#### 4. Land Resources

As used here, the term "land resources" applies to those surface oriented activities and operations affecting the surface as distinguished from air and subsurface resources. Mitigating measures include those applying to multiple use of the surface, protection of aesthetic values, erosion control, and land stability problems, including land subsidence and seismicity.

Scenic values are of particular importance to recreational uses. The major unfavorable impact of extensive geothermal development in the area under consideration may be on aesthetic or visual qualities inasmuch as most of the lands are under heavy recreational use. It would not be possible to fully mitigate the impact of industrial development upon aesthetic values.

Section 3204.1(f) of the leasing regulations requires that aesthetics be taken into account in the planning, design, and construction of facilities. Careful planning, design, and supervision of operations should lessen the undesirable impact of such operations. Under Section 270.34 of the operating regulations, each operation (building roads, drilling wells, constructing facilities, etc.) will require a Plan of Operation for the area which must be approved by the surface land management agency and the Supervisor. Mitigating factors that could be considered to lessen visual impacts include minimizing land use and disturbance by using existing roads and power transmission lines and possible use of directional drilling from central drill sites to minimum disturbance since all drill sites, production pipelines, and generating plant could be contained within a smaller area.

The overall visual impact would be lessened if operations could be conducted out of sight of main public access routes or recreational sites. This could be accomplished in part by careful site selection such as operating behind ridges, in forested areas, etc. Where such siting is impractical, appropriate consideration should be given to limiting drilling or excluding significant construction within a protective corridor adjacent to critical road sections or recreation sites. For the Mammoth area, such roads might include sections of U.S. 395, Hot Creek Road, U.S. 203, Owens River Road, Dry Creek Road, Deadman Road, Little Antelope Road, and Benton Road. Such restrictions would be developed on a case-by-case basis. The unused portions of operational sites should be restored to their original natural state as soon as possible. Temporary access roads could be scarified and reseeded. After completing wells, most of the area occupied by equipment and sumps could be replanted, using native plants for revegetating where possible.

Facilities should be blended into the background as much as possible to minimize the contrast with the natural setting. Power plant buildings could be designed with minimum profiles. Facilities and pipelines could be camouflaged by proper selection of paint color and landscaped with screening vegetation. Access roads might be less conspicuous if constructed with meandering rather than straight geometric routes provided the increased length does not impose other significant environmental impacts. The same principle would apply to well and plant sites; irregularly shaped sites retaining as many clumps of native vegetation as practicable would be more pleasing to the eye and could facilitate restoration to their native state more easily upon abandonment or reduction in used area.

No matter what type of power generating process is utilized, produced hot water or steam will have to be piped to power stations and waste fluids will have to be piped to injection wells. Extensive pipeline systems of probable large diameter may be involved, with potential significant visual impact. If all pipelines could be buried, most of the visual impact would be eliminated, but this may not be possible from geologic, engineering, safety, and economic standpoints. The transportation of high temperatures

causes severe expansion and contraction on startup or shutdown which might make burial unsafe and impractical. Pipelines could be camouflaged by proper landscaping which would mitigate much of the impact.

The basic guidelines that will be used to maintain the desired visual quality standard will be those now in use by the Forest Service in the area. Visual alterations to the Mammoth-Crowley Lake "grandfather" area will be required to follow these visual quality standards subject to further evaluation and determination of applicable requirements on a site-by-site basis as individual leases are considered.

The Forest Service presently uses a visual quality standard in identifying and cataloging national forest land as to its scenic quality, visual sensitivity, and its ability to undergo visual modification. These standards represent visual goals identified as follows:

1. Preservation - Provides for ecological changes only. No management activities allowed. (None of the Mammoth-Crowley Lake "grandfather" area falls into this classification.)

2. Retention - Requires management activities to blend into the natural landscape and not be visually apparent to the casual forest visitor. (Much of the western portion of the Mammoth-Crowley Lake "grandfather" area is so classified.)

3. Partial Retention - Management activities may be evident to the casual forest visitor; however, activity must remain subordinate to the visual strength and natural character of the landscape. (Much of the eastern portion of the Mammoth-Crowley Lake "grandfather" area is classified in this or a less restrictive classification.)

4. Modification - Management may be visually apparent to the casual observer and may become dominant in the landscape.

5. Maximum Modification - Management activities may completely subordinate the original landscape character. The amount of modification may exceed 25 percent of area seen. When viewed as foreground or middleground, the management activity may be totally dominant and may not appear to completely borrow from naturally established dominance factors. When viewed as background, the visual characteristics of the management activity must be those of natural occurrence.

The Mono-Long Valley area has been cataloged by the Forest Service for visual quality as shown on Figure M-15. To meet these visual goals, close liaison between the Federal agencies and private industry will be required when geothermal development is planned and commences.

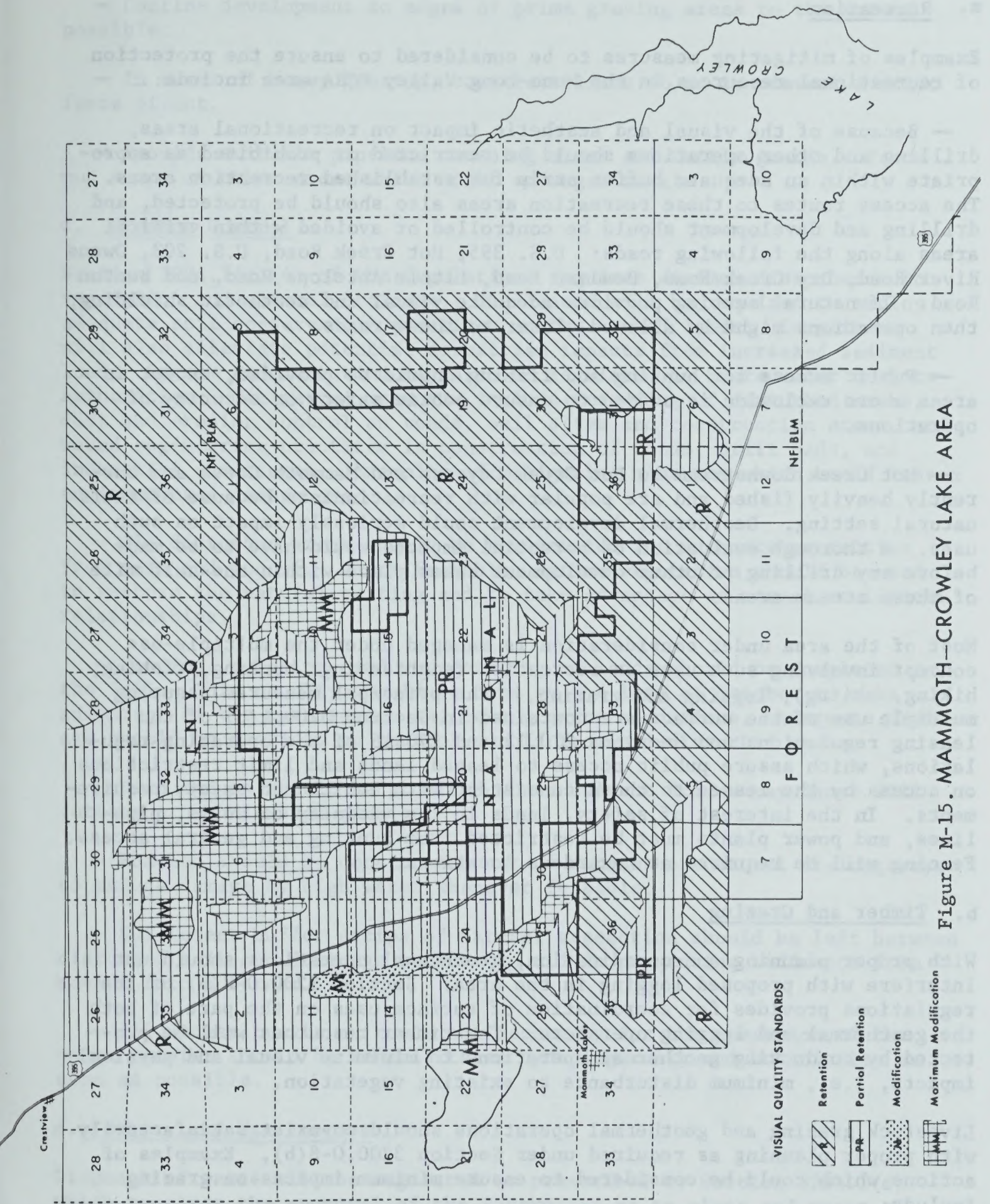


Figure M-15. MAMMOTH-CROWLEY LAKE AREA

#### a. Recreation

Examples of mitigating measures to be considered to ensure the protection of recreational resources in the Mono-Long Valley KGRA area include:

— Because of the visual and aesthetic impact on recreational areas, drilling and other operations should be restricted or prohibited as appropriate within an adequate buffer strip for established recreation areas. The access routes to these recreation areas also should be protected, and drilling and development should be controlled or avoided within critical areas along the following roads: U.S. 395, Hot Creek Road, U.S. 203, Owens River Road, Dry Creek Road, Deadman Road, Little Antelope Road, and Benton Road. If natural setting provides adequate visual and aesthetic shielding, then operations might be allowed closer to these roads.

— Public access for hunting and fishing should be provided, except in areas where exclusion is needed to ensure public safety or security of operations.

— Hot Creek downstream to Hot Creek Geysers and Mammoth Creek are currently heavily fished and are popular with recreationists because of their natural setting. Geothermal development could seriously impact on such uses. A thorough evaluation of potential impacts would have to be made before any drilling or other development takes place within one-half mile of these stream areas.

Most of the area under consideration is managed under the multiple-use concept involving such uses as recreation (sightseeing, hunting, fishing, hiking, skiing), logging and grazing. The principal measures assuring multiple use of the surface are contained in Section 3204.1(b) of the leasing regulations and Sections 270.11 and 270.15 of the operating regulations, which assure public access to leased lands and limit restrictions on access by the lessee to those consistent with health and safety requirements. In the interest of safety, lands in the vicinity of wells, pipelines, and power plants must be restricted from hunting and general access. Fencing will be required at hazardous locations.

#### b. Timber and Grazing

With proper planning and coordination, geothermal operations should not interfere with proposed logging in the area. Section 3200.0-8(b) of the regulations provides for coordination of surface uses on the part of both the geothermal and logging operators. The timber resources will be protected by conducting geothermal operations to minimize visual and physical impacts, i.e., minimum disturbance to existing vegetation.

Livestock grazing and geothermal operations should co-exist satisfactorily with proper planning as required under Section 3200.0-8(b). Examples of actions which could be considered to ensure minimum impacts on grazing include:

- Confine development to edges of prime grazing areas to the extent possible.

- In areas of heavy grazing, construct lines so as to prevent a drift fence effect.

- Provide suitable pipeline crossing areas and cattle guards. Fence mud sumps or other areas which might endanger cattle.

c. Erosion Control

Section 3204.1(c)(4) of the regulations requires minimum disturbance to vegetation and natural drainage. The lessee will be required to employ adequate soil conservation practices on the leased lands. Compliance will also alleviate potential downstream impacts from increased sediment load. Stream sedimentation may also be regulated by State water quality authorities. Mitigating measures include reseeding of disturbed areas, dust and erosion control on roads, well sites and construction areas, and sound engineering practices in construction of roads, drill pads, and industrial structures. Examples of mitigating measures which could lessen environmental damage are:

- All disturbed areas should be revegetated for adequate protection from rain and runoff. Where feasible, native vegetation should be used to restore the natural setting and to take advantage of normal ecological relationships.

- Seeding, mulching, and revegetating of lands should be completed in the fall. This usually should be done by the last of October to take advantage of the rain season and best growing conditions. Adequate drainage should be provided to control runoff from all disturbed areas.

- Down spouts should be provided where culvert drains may cause fill cutting or accelerated erosion.

- Roadbed should be constructed out of streams or natural drainageways to reduce damage by high water whenever feasible.

- Sufficient buffer strips of natural vegetation should be left between disturbed soil and drainage bottoms to aid in preventing sediments from moving into a stream.

- All access trails or roads not necessary for the operation of the power complex should be rehabilitated hydrologically and botanically as soon as possible.

d. Other Land Use Factors

Disposal of waste will be regulated as prescribed by Section 3204.1(d) which requires the approval of the Supervisor as to place and means of

disposal. This can be of particular significance in areas of high scenic or recreational use values. As noted in the section on air quality, open-burning must be in compliance with 40 CFR 76.

Upon completion of operations, and before termination of responsibility, the lessee will be required to restore disturbed lands as near as reasonably possible to their original condition.

Lands in the Mono Lake-Long Valley area are relatively stable and free from landslides. Small-scale earth movements can be expected if roads are not properly constructed. Compaction of fill, provision for adequate drainage, revegetation of disturbed lands, and application of sound geologic engineering judgment in the siting of structures and wells will be required to minimize the potential for land failures.

Development of a producing field in the area may result in reservoir pressure decline and possible compaction of reservoir rocks and surface subsidence. The only practical technique for alleviating compaction of reservoir rocks is reservoir pressure maintenance. As geothermal development will be in a liquid dominated system, reinjection of the liquid and steam condensate fraction may be sufficient to maintain reservoir pressures. If subsidence develops and proves to be a problem, fluid injection in excess of geothermal fluid disposal may be necessary. Because of the lack of developments which may be susceptible to damage due to subsidence outside of the geothermal development itself, a certain degree of land subsidence may be tolerable. A program of repetitive precise leveling over a network of stations will be required to detect and monitor subsidence. Remedial measures to stop subsidence once it is detected would be based upon assessment of the significance of this problem. Control measures could include reduced fluid withdrawal, increased fluid injection or, if necessary, the stopping of production.

Seismic activity may result from geothermal fluid withdrawal and/or reinjection of waste waters into the geothermal reservoir. Seismic activity should be monitored to properly evaluate the influence of geothermal development on seismic occurrences. There has been no monitoring of natural seismic activity in the area aside from locating major earthquake epicenters from permanent monitoring stations outside of the area. A long-term seismic monitoring program would require an array of continuously operated seismographs comparable to that of the test described by Hamilton and Muffler (1972). If a geothermal field capable of supporting commercial production is developed, a seismic monitoring network would be installed and operated. If it is shown that geothermal development has increased seismic activity and this activity is of such a magnitude as to pose a hazard to local and/or geothermal activities, the production of geothermal fluids may be restricted as appropriate. There is presently no means of controlling seismicity resulting from fluid withdrawal or reinjection except through regulation of formation pressure.

e. Power Transmission Facilities

Power line requirements and locations for the collection, transmission, and distribution of as much as 1,750 Mw of potential geothermal capacity cannot be developed until the geothermal potential has been further explored, developed, and brought into production. A 115 kv line presently crosses the western portion of the Mammoth-Crowley Lake "grandfather" area. Photo M-11 shows this line in its environmental setting at Casa Diablo Hot Springs in the southwest corner of the area. Existing and planned power generation and transmission systems were discussed in the description of the environment for this area.

Geothermal leases and related land use permits will provide for those portions of the power collection and transmission system as are necessary to transmit the power to primary transmission lines. Accordingly, they will relate to individual leases rather than to the total power grid system. Major transmission systems would be subject to separate land use permits that would be issued by the responsible land management agencies. Appropriate environmental considerations would be included in such permits.

A power demand of 53 Mw has been projected for the Mammoth area for 1980. Use probably will continue to grow rapidly thereafter. Accordingly, it is possible that the initial geothermal power production could be used within or adjacent to the Mono-Long Valley KGRA area. This could require a somewhat different collection, transmission, and distribution system than would be required if local power needs were to be met from external sources. Since individual generation installations would be small, initial geothermal developments could fit well into production and transmission to the various use areas. However, if the energy potential should be of the magnitude estimated, a major portion of the power eventually would have to be exported to other southern California areas. To the extent that alternative generation sources for these areas are not needed as a result of geothermal power, there could be significant environmental advantages to other areas.

Since major transmission facilities generally will not relate directly to individual leases, close coordination will have to be maintained among the Federal agencies involved, power companies, and individual geothermal developers through all phases of development to achieve proper planning that will assure that efficient systems are developed and that environmental impacts will be held to acceptable limits.

The construction of transmission facilities on geothermal lease and related land use permit areas will be subject to the same types of environmental protection measures as relate to other improvements with appropriate modification as necessary for any special problems such lines may present (i.e., protection of birds from electrocution; recreation uses; visual impacts; etc.).

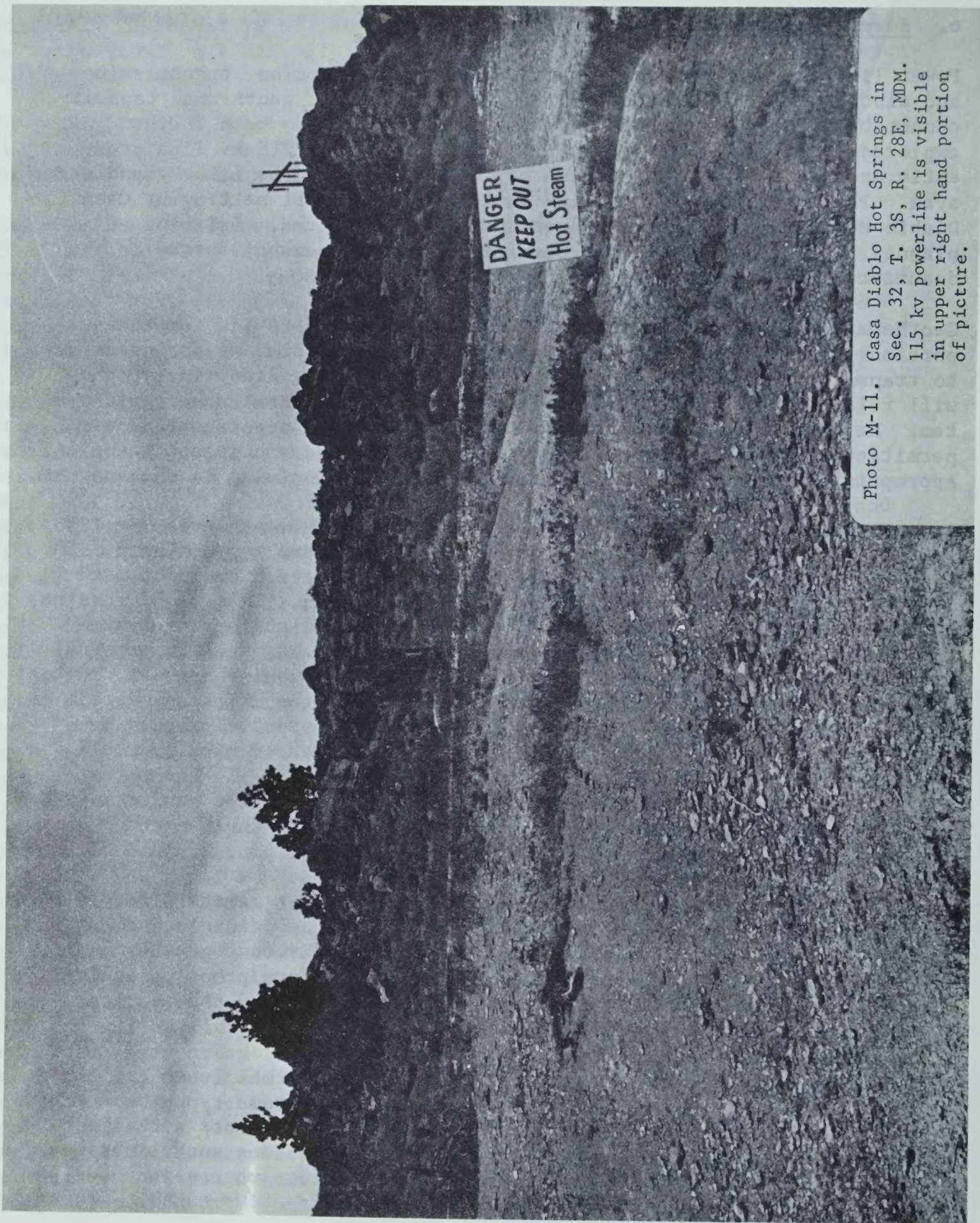


Photo M-11. Casa Diablo Hot Springs in Sec. 32, T. 3S, R. 28E, MDM. 115 kv powerline is visible in upper right hand portion of picture.

## 5. Air Resources

General provisions for prevention of air pollution and related employee health and safety are included in the proposed leasing regulations, Sections 3204.1(c)(3), 3204.1(c)(5), and 3210.2-1, and in the proposed operating regulations, Sections 270.30, 270.40, 270.41, and 270.46. In addition, the various Federal and State regulations dealing with air quality are applicable. County or other local government standards or regulations also will be applied as appropriate. Lease stipulations or GRO orders will include appropriate air quality provisions (Section 270.11). Technologic means can achieve mitigation of air pollution and related health and safety hazards. A more complete discussion of mitigating measures is presented in Volume I, Chapter III, Section C, Part 3b of this statement.

### a. Gases and Vapors

Release of gases and vapors associated with geothermal steam to the atmosphere must be in accord with national and State primary and secondary ambient air quality standards, safety and health standards, lease stipulations, GRO orders, or other instructions. Geothermal developments must conform to the State of California ambient air quality standards.

Monitoring, as required by Section 270.34(g) of the operating regulations, will be used to determine the quantities and types of atmospheric pollutants created by geothermal activities to assure compliance. Because of limited geothermal developments in the Mono Lake-Long Valley area, present air quality can be measured and used to authenticate any air quality degradation resulting from geothermal developments. Any measures, in addition to existing Federal and State standards, necessary to adequately maintain the quality of the environment in the area will be included in leases as lease stipulations or will be issued as GRO orders or other special instructions.

The most probable potential source of significant air pollution from geothermal operations is expected to be hydrogen sulfide gas. It is anticipated that large-scale geothermal development would be from deeper and different reservoirs than those presently tapped by existing wells at Casa Diablo. The hydrogen sulfide content is yet unknown, but this gas is generally associated with geothermal waters. Unpleasant odors could have significant impacts on areas of intensive recreation use so adequate controls will be required to hold such impacts to acceptable levels.

Noncondensable geothermal gases may be emitted to the air from three primary sources: well or pipeline venting; noncondensable gas vented from steam turbine generator barometric condensers; and cooling tower vapors (if geothermal waters are used for cooling). Air quality impacts from venting wells or pipelines can be mitigated by controlling emissions to short duration. This should not be a significant source of air pollution.

Emissions of polluting quantities of hydrogen sulfide from steam generator plants could be a more serious problem, but encouraging progress is being made at The Geysers plants to control such emissions. It should be noted that there would be no generating plant gas emissions if the Magmamax or other binary type power systems are utilized since these are closed systems where the geothermal fluids are not exposed to the air from production through injection.

Potential pollution from cooling towers could occur if these towers use produced geothermal waters or condensed steam. If outside water sources are used, they would not contain noxious gases. Chemical treatment of geothermal cooling waters should give reasonable control. Intensive studies now under way at The Geysers indicate that adequate control measures can be taken to meet air quality requirements.

Another possible solution to mitigate air pollution would be to use forced-air cooling. This type of cooling involves air only. No geothermal or turbine fluids are exposed to the air; hence, there would be no gaseous pollution. Such systems are more expensive than water tower coolers but might be economically justified due to lower-than-average ambient temperatures in this area.

Ambient air-quality standards have not been established for other gases and vapors which may be emitted from wells in the Mono Lake-Long Valley area. Because of local weather inversions, release of gases and vapors which are normally below health and safety standards may lead to a buildup to critical levels during periods of such inversions. Gases such as carbon dioxide, ammonia, mercury vapor, fluorine, radon, etc. associated with geothermal fluids may, on occasion, reach hazardous levels. Because of the limited data on the makeup of the noncondensable gas fraction and atmospheric conditions in this area, it can only be surmised that a problem may exist. It is possible that carbon dioxide and hydrogen sulfide will be the only gases associated with the geothermal fluids and will be of sufficiently low concentration as not to be a problem or they could be subject to adequate control systems. Lease stipulations or other special instructions will be issued as appropriate to control emissions of gases beyond established air quality and health and safety standards. Most noxious and hazardous gases can be removed from the noncondensable gas fraction through chemical means and many successful methods are presently being employed by other industries to meet air quality and healthy and safety standards. The economics of these processes may not, however, be within acceptable limits for geothermal power production. Development of less costly techniques for gas removal may be required to solve emission problems for potential power plants in the Mono Lake-Long Valley area.

Release of water vapor from evaporative type cooling towers may contribute to fogging under certain winter weather conditions, in addition to that which is normal for the area. As previously indicated, it is conceivable that certain noncondensable gases, primarily hydrogen sulfide, could accumulate to toxic levels under prolonged temperature inversion conditions. Because

geothermal power generated in the area will be base load rather than peak load power, generators and cooling towers would be in continuous operation and water vapor, and possibly other gases, would be continuously vented to the atmosphere. Thus, contribution of water vapor and potential increase in local fogging could be difficult to control. Reduced power production or flexible maintenance schedules may allow a power plant to reduce vapor additions to the atmosphere when weather conditions become severe. Additionally, certain mechanical controls may be developed to reduce vapor emissions on days when weather conditions are conducive to fogging. Such control techniques do not now exist. As geothermal development progresses, particular attention will be given to the potential need for special controls or stipulations that will be required to cope with such problems if they should pose unacceptable environmental or public health and safety hazards.

Adequate monitoring to detect any buildup of gases to toxic levels will be required and appropriate mitigating measures such as decreasing or temporarily shutting down power generation or control of noxious gases from vents or cooling towers will be required.

#### b. Dust and Vehicles

Methods are available to treat roads and construction sites to minimize dust generation. Watering of roadways and excavations holds down dust and is a method frequently used on temporary roads during periods of heavy traffic. Oiling or chemical treatment of roads is more effective in reducing dust; however, since it is more expensive than watering, such practices generally are restricted to use on more permanent roads. Paving of roads provides a long-term solution to vehicle-generated dust but, due to cost, is generally used only for permanent roads. Paving can be expected only if power plants are constructed in a geothermal field. GRO orders to control the generation of dust will be issued as appropriate by the Supervisor.

Vehicle and power source emissions can contribute to total air quality degradation to which State and national primary and secondary ambient air quality standards apply. The California State Motor Vehicle Pollution Control Standards, which currently are more strict than the Federal standards, are applicable. GRO orders will be issued as necessary to achieve adequate control of emissions from vehicles and internal combustion power sources.

#### c. Noise

Objectionable noise from geothermal activity is not regulated by any existing Federal or State laws. Appropriate lease stipulations regulating emissions of objectionable noise, such as those presented in the general statement, will be included in leases, and other instructions will be issued as appropriate in GRO orders or other instructions. Noise standards

for geothermal development as established by county ordinance will be adopted as appropriate by lease stipulation or GRO order. Several muffler designs have been successfully tested at existing geothermal fields. Continued improvement of muffling equipment for both wells and well drilling rigs is expected. Appropriate muffling equipment will be required under GRO order or lease stipulation for use on wells on all Federal leases. Under existing technology, objectionable noise emissions as a result of geothermal development is not expected to be a serious problem.

#### d. Burning

Burning of trash on Federal lands is regulated under provisions of 40 CFR 76, which may be supplemented by GRO order or lease stipulation. Geothermal activities are not expected to greatly increase the hazard of accidental fires to forest lands in the area over that already present due to the high recreational usage of the land. Fire prevention equipment maintained by the operator to safeguard geothermal equipment and materials may increase the total fire fighting capability in the area. Proper fire prevention and maintenance measures by geothermal operators, plus additional fire fighting equipment of the operators, may lead to a reduction in overall adverse effects of fires in the area.

#### 6. Archaeological and Historical Values

Regulation Section 3204.1(h) states: "The lessee shall conduct activities on discovered, known, or suspected archaeological, paleontological, or historical sites in accordance with lease terms or specific instructions."

Preserving and protecting the archaeological values of an area may require avoiding disturbance or salvage excavation. In some instances, as with wood structures, it may be possible to move them, but salvage excavation still may be necessary. Avoiding disturbance should be given preference whenever feasible for it best protects the archaeological resource.

Where there is high probability of significant values, an archaeologist should evaluate lands prior to development. The archaeologist can identify sites so that roads and other earth-disturbing activities can be planned to avoid disturbance of the archaeological values, or such values can be otherwise protected or salvaged as appropriate. If the archaeological values are of high significance, it may be appropriate to permit no development so the site can be preserved. Such determinations will be made on a case-by-case basis.

Earth-moving type construction or development will be carefully planned and controlled on known or suspected archaeological sites of potential significance. When unknown sites are uncovered during operations, the operations shall cease until the area can be assessed for archaeological value and the best methods and need for salvage or protection determined. Use of existing roads and trails will help to mitigate any impacts on the archaeological resource.

Movement of equipment on or over sites should be avoided. If it is necessary to cross archaeological sites which do not have destroyable aboveground features, precautionary measures such as planking or rubber tires should be used to avoid compaction.

No activity should take place on any known cemetery or burial grounds of any group or culture. Suspected areas should be thoroughly investigated before any development disturbance is permitted.

In areas of high visitor use potential, special planning should be done to keep permanent damage, scars, and developments out of the view of the visitor. Techniques such as are discussed in the Aesthetics section will be used.

Where adverse impacts are anticipated on sites listed, or proposed to be listed, on the National Register of Historic Places, a special statement to the President's Advisory Board on Historic Sites is required.

Prevention or mitigation of potential fire damage can best be accomplished by strict enforcement of fire prevention and control laws and regulations and by using precautionary measures such as construction of fire lanes around timbered sites, buildings, and other high value areas.

The most sensitive archaeological areas are those within one-half mile on each side of Hot Creek, areas within one-quarter mile of any spring or stream, or the immediate vicinity of cave or rock shelters. Figure M-16 reflects the general archaeological sensitivity ratings in the Mammoth-Crowley Lake area.

In advance of geothermal development, the involved Federal agencies will agree on the measures to be taken to protect and preserve historic buildings and sites. The measures shall depend upon the exploration or development techniques to be used and the historic site or building involved.

Archaeological and historical sites found and determined by the archaeologist and the Federal agencies to be of high value for either science, history, or recreation shall be protected in a manner determined by the Federal agencies that will preserve those values for future use.

Exploration and development will be carefully planned and controlled where such activities could have adverse impacts on any historical site or building included, or proposed to be included, in the National Register of Historic Places. In each lease area where significant archaeology values are found that must be preserved, the authorized officer will determine the controls necessary and set forth stipulations to protect a particular site and values.

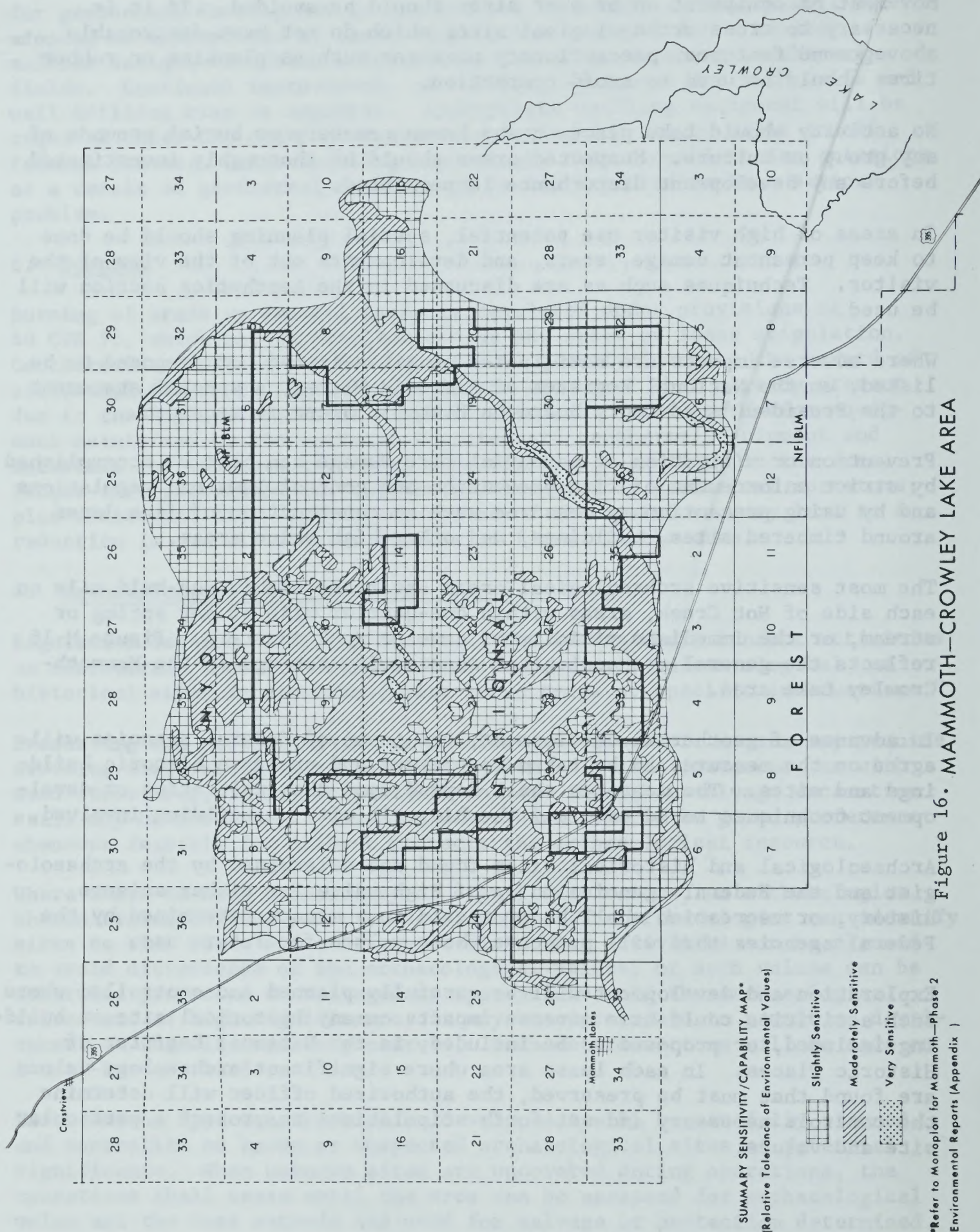


Figure 16. MAMMOTH-CROWLEY LAKE AREA

## 7. Water Resources

### a. Water Supply

The principal consumptive use of water in a geothermal development is for cooling. In the case of electric power plants, the geothermal fluid itself may be the source of supply for the cooling water requirements of the plant.

Data from The Geysers geothermal operations indicate a consumptive water use of about 46 acre-feet per year per megawatt of plant capacity. Similar rates of consumption probably would apply to geothermal steam turbine systems of the hot water type. The cooling requirements for binary cycle systems probably would be slightly greater than for steam turbines.

### b. Water Quality

Under the Federal Water Pollution Control Act, as amended, the primary responsibility for water quality is assigned to the States. Each State is required to promulgate interstate water quality standards which then must be approved by the Environmental Protection Agency. California has federally approved standards. The State of California antidegradation statement, approved January 9, 1969, provides the following policy guidelines:

"Whenever the existing quality of water is better than the quality established in policies as of the date on which such policies become effective, such existing high quality will be maintained until it has been demonstrated to the state that any change will be consistent with maximum benefit to the people of the state, will not unreasonably affect present and anticipated beneficial use of such water and will not result in water quality less than that prescribed in the policies.

"Any activity which produces or may produce a waste or increased volume or concentration of waste and which discharges or proposes to discharge to existing high quality waters will be required to meet waste discharge requirements which will result in the best practicable treatment or control of the discharge necessary to assure that (a) a pollution or nuisance will not occur and (b) the highest water quality consistent with maximum benefit to the people of the state will be maintained."

In California, water quality responsibility is vested in the State Water Resources Control Board. Enforcement of State-Federal regulations is carried out by nine regional water quality control boards. The Mono Lake-Long Valley area is in the area of jurisdiction of the Lahontan Regional Water Quality Control Board located at Bishop, California. Water-pollution control is exercised by the regional boards by the procedure of waste-discharge orders issued for specific waste-discharge situations.

Within the Mono Lake-Mammoth-Crowley Lake "grandfather" area, the Lahontan Regional Water Quality Board has jurisdiction. Actions of the Regional Board are directed toward implementing the following goals:

- Protection and enhancement of all Basin waters, surface and underground, for present and anticipated beneficial uses.
- Management of municipal and industrial waste waters as part of an integrated system of fresh water supplies to achieve maximum benefit of fresh water resources.
- Maximize use of fresh waters through recycling for agriculture, industry, and municipalities.
- Continual improvement of waste treatment systems to assure consistent high quality effluent at minimum cost.
- Development of planned systems for water use and waste discharge to assure protection of water resources for present and future beneficial uses and to achieve harmony with the natural environment.
- In certain Basin areas, maintenance of natural water quality unaltered by waste discharge.

Management Principles -- To implement its goals, this Regional Board will direct its activities toward the following objectives:

- Water quality management systems shall, wherever possible, provide for eventual waste water reclamation unless such reclamation is precluded by processing costs or lack of projected demand for reusable water.
- The number of waste sources and independent treatment facilities shall be minimized, and consolidated systems shall maximize their capacities for waste water reclamation, assure efficient waste management, and meet potential demands for reclaimed water.
- Disposal of economically reclaimable waste water by evaporation shall be discouraged.
- Industrial and municipal effluents discharged to waters of the Owens Valley watershed shall contain essentially none of the following substances:

- Chlorinated hydrocarbons
- Toxic substances
- Harmful substances that may enter food webs
- Excessive heat
- Radioactive substances
- Grease, oil, and phenolic compounds

Excessively acidic and basic substances  
Heavy metals such as lead, copper, zinc, mercury, etc.  
Other deleterious substances

- Waste water discharged for percolation into ground waters of the basin shall be of such quality at the point of discharge as to assure continued protection of beneficial uses.
- Waste waters discharged for percolation into usable ground waters shall not contain toxic substances in excess of accepted drinking water standards.
- Waste waters discharged for percolation into usable ground waters shall not contain nitrogen or nitrogenous compounds in amounts which could result in nitrate concentration in the ground waters above 45 mg/l.
- Taste- and odor-producing substances and detergents shall be essentially completely removed from waste waters prior to discharge in areas where it is expected that percolation into ground water will occur without benefit of passage through a suitable soil zone of aeration.
- In all ground water basins known to have an adverse salt balance, the total salt content of waste discharges which percolate to ground water shall not exceed water supply concentrations plus incremental increases normal to domestic water use.

The Lahontan Board has adopted a "no degradation" policy with regard to water quality. The general objectives for water quality protection are listed below:

- Color - No significant increase beyond natural background levels.
- Turbidity - No significant increase beyond natural background levels.
- Bottom Deposits - None other than of natural causes.
- Floatables, Oil, and Grease - No visible effect other than of natural causes.
- Odors - None other than of natural causes.
- Pesticides - No individual pesticide or combination of pesticides shall reach concentrations found to be deleterious to fish or wildlife. There shall be no increase in pesticide concentrations over background levels in indigenous aquatic life.

- Biostimulants - No substance which produces aquatic plant or animal growths in the receiving waters to the extent that such growths cause nuisance or damage any of the beneficial water uses shall be added.
- Radioactivity - Radionuclides shall not be present in concentrations that exceed the maximum permissible concentration for radionuclides in water as set forth in Chapter 5, Title 17, of the California Administrative Code.
- Bacteria - None attributable to human wastes.
- Toxicity - At all times less than the concentrations toxic or harmful to humans including but not limited to those substances specified in the United States Public Health Service Drinking Water Standards. At all times less than the concentrations toxic or harmful to aquatic life or which would render aquatic life undesirable for human consumption.

Numerical Objectives -- Sufficient data are not available at this time to establish meaningful numerical criteria for the various water quality parameters of importance in surface and ground water of subbasins with the South Lahontan Basin. It is hoped that the complexities of the basin will be better understood so as to enable the establishment of rational numerical objectives prior to adoption of fully developed Basin Plans in 1973.

On an interim basis, pending establishment of specific numerical objectives, a general statement of intent to maintain the quality of surface and ground waters of the basin at the highest possible level and protect and preserve them for present and future beneficial uses will be the Board's guiding water quality objectives.

Prohibitions -- In the interest of achieving the foregoing goals and objectives, the Lahontan Regional Board adopted the following prohibitions:

1. The discharge of waste to surface water is prohibited in the following locations:

- a. The Owens River and tributaries upstream of Crowley Lake above elevation 7200 feet.

2. The discharge of surface water of liquid or solid materials such as soil, silt, sand, clay, and other earthen materials as a result of construction, excavation, grading, clearing, logging, or other activities of man which disturb the natural ground conditions is prohibited in the following areas:

- a. Mono Lake Sub-Basin
- b. Owens River Sub-Basin

Order No. 6-71-21 (Exhibit M-1, p. V-266) illustrates how the Lahontan regional procedure is applied to the wells in the Mono Lake area.

Under Section 3204.1(c)(2) of the leasing regulations and Section 270.41 of the operating regulations, compliance with Federal and State water quality and health and safety standards will be required of lessees of Federal lands. Local regulations also will be utilized as appropriate.

Toxic materials shall not be released to any surface or underground waters. Reinjection of waste geothermal fluids into geothermal or other suitable aquifers may be permitted upon approval of the Supervisor. It is expected that all waste fluid from Federal geothermal leases in the Mono Lake-Long Valley area will be returned to the producing reservoir, except for possible releases to Mono Lake subject to approval of the Regional Water Quality Control Board.

It should be noted that Waste Discharge Order No. 6-71-21 also addresses the problems of disposal of drilling fluids, toxic materials, and sediment yield to streams of the area. These provisions would likewise be applicable to Federal leases.

Analysis to determine the radioactivity of fluid will be required for each well drilled on Federal leases. If such analysis indicated that a health hazard exists, GRO orders will be issued requiring adequate health and safety precautions and periodic monitoring as appropriate. If radioactivity should be of such nature that it could not be held to acceptable levels, then production from such wells would not be permitted until such time as new technology or systems are available to assure adequate health and safety protection.

## 8. Fish and Wildlife

There is a wide diversity of vegetative cover and fish and wildlife habitats and populations in the Mono-Long Valley KGRA could be affected by geothermal development. It is not possible to develop a single comprehensive set of mitigating measures that adequately would cover all situations, so the proposed leasing regulations include adequate provision for inclusion of appropriate protection measures in each lease and its related operational orders.

Section 3204.1(g) requires that the lessee shall employ such measures as are deemed necessary to protect fish and wildlife and their habitat. Section 3204.1(i) provides that the lessee shall provide for the restoration of all disturbed lands in an approved manner. Necessary fish and wildlife protection and land restoration measures will be developed on a sensitive basis and included as appropriate as special stipulations in each lease or as GRO Orders.

Land areas to be used for the generation facilities, roads, etc. would remain cleared with resultant loss of plant cover and wildlife habitat.

**CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD  
LAHONTAN REGION**

Board Order No. 6-71-21

**Waste Discharge Requirements  
for  
GEO THERMAL RESOURCES - MONO COUNTY**

The California Regional Water Quality Control Board, Lahontan Region, finds:

1. The Geothermal Resources International, Inc. submitted a report of waste discharge dated May 17, 1971.
2. The Geothermal Resources International, Inc. proposes to discharge an indeterminate amount of water produced from geothermal exploration wells into Subareas 2 and/or 4 of the Mono Lake Sub-Basin at a point 5 miles east of the community of Lee Vining in Sections 17 and 20, T1N, R27E, MDB&M in Mono County.
3. The Board adopted an Interim Water Quality Management Plan for the Mono Lake Sub-Basin on June 11, 1971.
4. The beneficial uses of Subareas 2 and 4 of the Mono Lake Sub-Basin include:
  - a. domestic supply
  - b. municipal supply
  - c. agricultural supply
  - d. industrial supply
  - e. power generation
  - f. recreation
  - g. esthetic enjoyment
  - h. preservation and enhancement of fish, wildlife, and other aquatic resources or preserves.
5. The Board has notified the discharger and interested agencies and persons of its intent to prescribe waste requirements for the proposed discharge.
6. The Board in a public meeting heard and considered all comments pertaining to the discharge.

IT IS HEREBY ORDERED the Geothermal Resources Company shall comply with the following:

**A. Waste Discharge Requirements**

1. The discharge shall not cause a pollution.
2. Neither the treatment nor the discharge shall cause a nuisance.

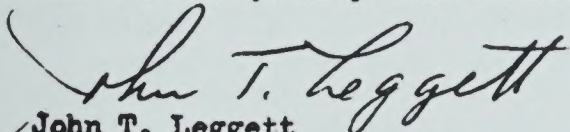
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3. There shall be no discharge to surface waters.
4. The discharge of waste from any percolation basin shall not contain toxic substances in excess of United States Public Health Service Drinking Water Standards.

#### B. Provisions

1. All facilities containing wastes which do not meet the requirements for percolation into groundwaters shall be effectively sealed by a method capable of preventing an exfiltration rate in excess of 500 gallons/acre/day.
2. The discharger shall comply with the Monitoring and Reporting Program No. 6-71-21 and the "General Provisions for Monitoring and Reporting" as specified by the executive officer.
3. In the event of any change in control or ownership of land presently owned or controlled by the discharger, the discharger shall notify this Board of such change and notify the succeeding owner or operator of the existence of this order.
4. Any proposed material change in the character of the waste or method of discharge or location of discharge shall be reported to this Regional Board.
5. The California Regional Water Quality Control Board, Lahontan Region, hereby reserves the privilege of changing all or any portion of this order upon legal notice to and after opportunity to be heard is given all concerned parties.

I, John T. Leggett, Executive Officer, do hereby certify that the foregoing is a full, true and correct copy of an order adopted by the California Regional Water Quality Control Board, Lahontan Region, on June 11, 1971.

  
John T. Leggett  
Executive Officer

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD  
LAHONTAN REGION

Attachment to Order No. 6-71-21  
Regarding

GEOHERMAL RESOURCES - MONO COUNTY

REQUIREMENTS AND RECOMMENDATIONS OF OTHER GOVERNMENTAL AGENCIES

Other governmental agencies have requested the inclusion of the following additional requirements and recommendations which are not directly related to water quality.

STATE DEPARTMENT OF PUBLIC HEALTH - BUREAU OF SANITARY ENGINEERING

1. The breeding of mosquitoes, flies and other vectors of public health significance, inasmuch as it results from this operation and disposal, shall be controlled.

\* \* \* \* \*

**CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD  
LAHONTAN REGION**

**MONITORING AND REPORTING PROGRAM NO. 71-21  
FOR**

**GEOHERMAL RESOURCES INTERNATIONAL, INC.**

**Drilling Mud Monitoring**

Complete records on drilling mud shall be prepared containing information on mud and mud additive quantity and composition.

**Geothermal Water Monitoring**

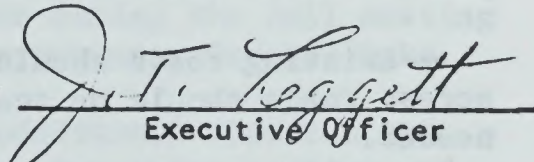
Representative samples of geothermal waters produced from exploratory wells shall be taken on each day such waters are produced. The monitoring program shall be as follows:

<u>Parameter</u>	<u>Units</u>	<u>Type of Sample</u>	<u>Sampling Frequency</u>
Total Filtrable Residue	mg/l	Grab	Daily
Boron	mg/l	Grab	Daily
Arsenic	mg/l	Grab	Daily
Sodium	mg/l	Grab	Daily
Fluoride	mg/l	Grab	Daily

**Reporting**

Weekly monitoring reports shall be submitted to the regional board commencing with the start of the exploration program. In reporting the monitoring data the discharger shall arrange the data in tabular form so that the date, the constituents, and the concentrations are readily discernible.

Ordered by

  
Executive Officer

June 21, 1971

Other areas subject to temporary use or disturbance would be subject to restoration. In some situations, such restoration could result in ground cover better than that which previously existed. Much of the disturbed surface vegetation and soil within road, power transmission or steam pipeline routes would be subject to soil stabilization, preparation, and seeding with appropriate wildlife food and cover species. Adequate erosion control and drainage measures will be required to mitigate soil movement from disturbed sites and the amount of silt entering water courses. All phases of exploration, development, and production operations will be monitored and inspected to ensure compliance with lease and GRO Orders. Fish and wildlife population surveillance will be maintained to detect significant adverse trends as a basis for implementation of necessary corrective actions.

A more detailed discussion of provisions for the mitigation of impacts on habitat and fish and wildlife resources is included in the general environmental impact statement (Volume 1, Chapter III). These include replacement of disturbed vegetation, land reclamation, prevention of electrocution of birds, public access to lease lands, and prevention of water pollution.

The following specific mitigating measures are examples of actions that may be required to avoid or offset the fish and wildlife losses that may occur with geothermal development in the Mono-Long Valley KGRA:

- Operating plans should be designed to result in the least disturbance of the soil and the native vegetation in the development area.

- Revegetate all exposed land as soon as possible after soil disturbance. Native plants should be given preference if they will afford adequate protection and restoration. Consideration also will be given to the use of legumes as well as annual and perennial grasses. Mulching and fertilizing may be needed in some areas. Optimum species determination can be made by local BLM, California Department of Fish and Game, or other sources.

- Construct wildlife watering devices where roads, well sites, or other developments alter natural springs. Such devices should not be placed closer than 50 feet from the edge of the development.

- Existing roads should be utilized whenever possible. All temporary access roads should be scarified and reseeded when they are no longer needed.

- Construction in meadows and riparian zones along streams and lakes should be avoided whenever possible. Also whenever possible, construction in ecotones should be avoided as these are productive wildlife habitat areas.

- Restock stream with trout in the event that geothermal development activities cause a significant fish population reduction. The need for restocking and the strain of trout will be determined in cooperation with State fish and game biologists.

- Where possible, native plants or other types of compatible vegetation should be used in landscaping buildings, parking lots, and other facilities. Adequate measures will be incorporated to minimize soil erosion. To the extent feasible, vegetative productivity should be maintained at the level existing prior to development and, whenever possible, projects should be designed so that vegetative communities can be improved to help offset the impacts of habitat losses elsewhere on the operating area.

- Power distribution lines should be designed and constructed in accordance with REA Bulletin 61-10 (Powerline Contacts by Eagles and Other Large Birds) in order to minimize loss of birds. Also, power lines should not disrupt sage grouse strutting grounds, nesting areas, and key winter ranges.

- Drilling should be avoided in meadow and riparian areas. Buffer strips around known nest trees for hawks and eagles should be maintained.

- Whenever feasible, snags should be left in place when vegetation is being cleared. Islands of vegetative cover should be left in areas cleared for ponds, parking areas, etc.

- Human disturbance on Negit Island should not be allowed during the gull nesting season.

- Water quality should be maintained at the current level in Hot Creek, Mammoth Creek, Owens River, Little Hot Creek, Crowley Lake, and Mono Lake. Water quality monitoring stations will be established on these drainages to measure the quality of the streams during the development and production stages.

- Noise levels during drilling, testing, and construction could have temporary impact on wildlife. Normally, this would be of relatively short duration and would be more in the nature of a disturbance rather than damage. However, if there are critical wildlife factors such as nesting seasons, migration routes in the Mono-Long Valley KGRA, etc., special noise control provisions should be required and, in especially critical areas or seasons, damaging noise levels should be prohibited. Each operating area will have to be carefully evaluated and appropriate restrictions imposed. Noise sensitive areas include Negit Island during the full nesting season, sage grouse strutting grounds and nesting areas near Crowley Lake.

The opening of new roads and trails may result in additional opportunity for public access which in turn could increase use. Resulting hunting and recreational use could impose additional pressures on fish and wildlife populations. By contrast, geothermal development may curtail some public hunting and recreational uses within lease tracts to assure public safety or to provide security for operations in the immediate vicinity of facilities. Such impacts are not expected to be significant. In the event problems are anticipated or detected, corrective measures would be taken as appropriate.

E. ADVERSE IMPACTS WHICH CANNOT BE AVOIDED SHOULD THE PROPOSAL BE IMPLEMENTED

Some environmental impacts will result from implementation of leasing and operational activities in the Mono-Long Valley KGRA. Potential impacts and mitigating measures associated with such activities have been discussed in the preceding sections.

Geothermal regulations, lease provisions, and General Resources Operational Orders are designed to assure that geothermal resources can be developed and utilized in an environmentally acceptable manner. In those instances where this cannot be done, development and use will not be permitted. However, virtually any human use of lands and their resources may have some degree of adverse impact. Where benefits warrant acceptance of minor impacts, such uses may be appropriate provided the adverse impacts have been adequately recognized, mitigated to the extent possible, and are not so serious as to preclude the proposed action. The following discussion summarizes the types of adverse impacts that may be unavoidable should the proposal be implemented.

1. Exploration Phase

Exploration activities in the Mono-Long Valley area will involve physical presence upon the land which may result in damages to the land and resources thereon. Exploration activities include, but are not limited to, geophysical operations, drilling of shallow temperature gradient wells, construction of access roads or trails, and cross-country transit by foot, animals, or vehicles.

Even though persons conducting exploration operations comply with all of the general and specific terms and conditions of the "Notice of Intent to Conduct Exploration Operations," including the restoration of areas as near as possible to their original condition, some adverse impacts still may result.

Vehicle travel will result in dust, exhaust gases, noise, disturbance of wildlife, injury or killing of wildlife, accidents, etc. When existing roads are used, such impacts would be nominal and the result of increased traffic. Advance approval will be required for construction of new roads or trails. However, there will be a certain amount of disturbance of vegetative cover and soil surface from cross-country travel on roads or trails that could have temporary impacts until cover is restored and soil is stabilized. Evidence of such roads or trails may remain for several years which could be conducive to casual use by others that could result in damage. Failure to comply with regulations or exploration stipulations could result in similar impacts but damages could be more significant, particularly if such improper use was not promptly detected and corrected. No serious unavoidable adverse environmental impacts are expected from exploration activities.

Drilling of shallow holes or blasting may result in minor vegetative and surface disturbance in the immediate area of activity. All drill holes will be small and shallow and are to be capped when not in use so no damage is anticipated from such holes. If not capped, small animals could fall into the holes and perish or larger animals could be injured if they stepped in open holes.

The presence of men and equipment presents an additional fire risk in forests and brush covered areas. Even though operators are required to make every reasonable effort to prevent, control, or suppress fires started by their operations, there can be accidents, human error or carelessness, equipment faults or failures, etc. which could cause fires that could have serious environmental consequences. Similar risks are associated with virtually any human use of such areas subject to serious grass, brush, or forest fires.

## 2. Test Drilling Phase

Following award of leases, heavy equipment capable of drilling to depths of several thousand feet would be required. The enlargement and improvement of existing roads or construction of new roads to provide access for drilling equipment and supplies to the drilling site could involve unavoidable impacts from vegetative cover removal, surface disturbance, cuts and fills for roadbed, soil erosion, and siltation during construction and, to a lesser degree, some impacts even after banks were stabilized, vegetative cover was restored, and adequate drainage was installed. At each drilling site a level area of approximately one-half to one acre is required for drilling operations. In hilly country, such as the Mono-Long Valley area, this could necessitate considerable grading. While compliance with lease and GRO Orders will prevent serious adverse impacts, some minor impacts will result. Most of the potential impacts listed under exploration could be expected with some intensification in areas of heavy activity.

During grading and drilling operations, moderate levels of noise from equipment operations would be unavoidable. Even where special noise control measures are required, noise levels will be above natural levels.

Physical land modification will be greater at this stage which could result in loss of wildlife habitat and wildlife values in the area of operation. Such impacts generally would be of a temporary nature. Some siltation or other degradation of surface waters may result from clearing and earth moving or from drilling operations which could result in localized damage to fish and wildlife. There could be some reduction of public activities to protect equipment and facilities and to reduce hazards to the public. Surface disturbance scars would be larger and possibly permanent in nature.

Well blowouts could result in venting of steam, associated gases and mineralized water to the atmosphere, ground area and surface water, creating air and water contamination, high noise levels, and exposing individuals to possible injury.

While modern drilling techniques are capable of preventing such accidents, there is still the possibility they may happen due to human error, equipment failure or other factors. Adverse impacts would continue until the blowout is controlled. The impact of the incident could range from minor to serious, depending upon location and duration of the blowout. Blowouts also could result from subsequent events such as earth slides, seismic action, vandalism, etc.

Accidental spillage of geothermal fluids, drilling mud, or other surface contaminants could damage the environment. For example, these contaminants could enter surface waters feeding Crowley Lake. While the probability of extensive damage may be low, the possible consequences to fish and urban water supplies or subsurface contamination are high and could constitute a hazard to human health and safety.

### 3. Production Testing Phase

In water-dominated reservoirs, production testing requires production of the formation fluid over an extended period. Disposal of produced water could have an environmental impact if the water, which is mineralized and contains toxic substances, should be accidentally released to the surface environment. Large volumes of liquids could be involved. If not properly contained or reinjected, they could seriously impact on surface water quality, related fish, wildlife, or other water-related values.

### 4. Full-Scale Operation Phase

Full-scale operation will require complete development of well and steam transmission systems, power generation facilities, transmission lines, permanent roads, etc. Many of the potential adverse impacts associated with exploration and testing will no longer exist but other impacts may increase in proportion to the scale of development. Currently about 10 wells are needed to supply each generating station in The Geysers, and more may be required in Mono-Long Valley. Each well will involve clearing, grading, and improvements. Steam pipelines connecting wells to the generators likewise require clearing and grading. During construction there will be considerable activity, noise, movement of earth, dust, etc. After construction is completed and all necessary environmental protection measures are taken, the nature of the site will be changed somewhat from its former natural state to an industrial type complex. Cuts, fills, clearings, buildings, power lines, etc. will represent permanent changes in the landscape.

Even with adequate controls, full-scale operations will involve higher than natural noise levels, emission of steam and other gases to the atmosphere, disturbance from operational activities, additional vehicle traffic, etc. Additional transmission lines will be a hazard to some wildlife as they may result in minor levels of electrocution of eagles, hawks, and other birds; however, the kill should be no greater than on existing lines built in connection with other power systems. Transmission lines damaged

from storms or other failures can result in fire or personal injury but to no greater extent than existing lines built in connection with other power systems.

Potential adverse impacts would be introduced during full-scale operation from possible land subsidence or increased seismic activity. However, a significant impact from these causes would not be expected until major production begins.

Land subsidence occurs because of compaction of reservoir materials as fluid is removed and reservoir pressure decreases. This is a consequence of fluid production followed by some compaction in a confined system with substantial pressure decline. The amount and distribution of subsidence is a function of pressure decline and physical character of the reservoir materials, especially their compressibility. Land subsidence due to fluid withdrawal occurs mainly in areas of poorly consolidated sedimentary rocks. Once subsidence occurs, it cannot be reversed, even by fluid injection. Water storage capacity would be correspondingly reduced.

Land subsidence roughly can be predicted from tests of core material prior to production, but the only precise measure is obtained by measurement of surface altitude before and during production. The impact of subsidence would be negligible in Mono-Long Valley because it is isolated and undeveloped. Wells penetrating compacting sections could be damaged by compaction.

One means of alleviating the potential subsidence problem and at the same time disposing of unwanted waste water is through pressure maintenance by reinjection of such wastes through wells completed in the producing zone or in another reservoir. However, this can lead to the potential adverse impact of increasing seismicity. The relationship of fluid-pressure changes to earthquakes is not well known and research in this field has barely begun. Impacts could be beneficial or adverse.

The intrusion of structures, pipelines, and additional transmission lines into this relatively undeveloped area will create an adverse visual impact. It could also tend to lessen the aesthetic value of this major recreation area. However, growing power demand will require additional transmission facilities to serve the area, regardless of the power source.

Extensive development could lead to damage of archeological sites presently unknown. Discovery of new sites by construction equipment could also be beneficial as well as destructive, depending on the amount of damage to the site before it is recognized.

Clearing operations inevitably will result in some removal of vegetative cover. Since Mono-Long Valley is timbered, loss in vegetative cover may represent a loss in growing stock as well as a loss in wood capital. The timber can be salvaged but some time will pass before planted seedlings reach pole-timber or small saw-timber size. Areas occupied by major facilities would be removed from timber production until operations cease and disturbed areas are restored.

While geothermal development will impose some unavoidable adverse environmental impacts, it appears to have the potential of being less environmentally damaging than other power generating systems using coal, oil, or nuclear energy sources. Much of the power generated in this KGRA probably would be exported to meet the needs of other southern California areas. The environmental considerations involve different southern California geographic and environmental settings but generally the same user or benefit groups would be involved as the heaviest recreational use of the Mono-Long Valley KGRA area is by southern California residents who are only 5 hours' travel away by highway and even closer by air. To the extent that there are net total system reductions in adverse air, water or land impacts, such differences represent positive benefits from the use of geothermal resources even though there will be local adverse impacts that cannot be avoided.

F. THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

1. General

The leasing of lands for geothermal resource development in the Mono-Long Valley KGRA involves the commitment of a portion of the geothermal heat, water, and related land areas and resources of the sites involved. The extent and nature of these commitments and an assessment of their potential environmental impacts have been described in detail in the preceding sections. It is particularly significant that the geothermal heat is a wasting resource that otherwise would be dissipated over time from the surface of the earth to the atmosphere with little or no identifiable benefit. By contrast, development of this resource in an environmentally acceptable manner can have substantial benefit by affording power generation, space heating, and water resources.

The exploration and testing phases of geothermal leasing are designed to determine the nature and extent of geothermal resources. Generally the active portion of this phase is of short duration, sometimes extending only over a period of days, months or, at most, a few years. It may be intensive and continuous for short periods or periodic over several years. Where such exploration proves unsuccessful there would not be subsequent use of the lands for development and production of geothermal resources.

Exploration and lease provisions require that lands disturbed by unsuccessful exploration will have to be restored as nearly as possible to their original condition upon termination of these activities. Such restoration would include: grading, installing proper drainage, soil removal or disposal of all wastes, filling in of holding ponds, etc. Except for leveled drill sites and roads, the areas should return to natural conditions in a short time. Changes in vegetative cover may result, depending upon whether native or non-native plants are used. In some instances, such changes could be beneficial for wildlife. In a few years, native vegetation probably will recover the area. Accordingly, there would be little or no long-term productivity impact on the areas involved.

The two dry holes drilled for geothermal resources on the shores of Mono Lake did not adversely affect the brine shrimp in the Lake or greatly disturb the local bird life. Road access to the short areas of "grandfather" lands exists. There would, however, be some disturbance of shore bird nesting on Negit Island from any major activity on Paoha Island. If no commercially valuable geothermal resources were discovered on the Island, shore birds would be scared away only during test drilling and production testing. Under such circumstances, no cumulative impacts upon bird use of Mono Lake should occur.

Where development and production occur, timing of such development will depend upon electric power markets, power transmission systems, construction schedules, etc. Once production begins, the geothermal resource probably

would be withdrawn at a rate greater than the natural replenishment rate. Over a period of years (perhaps 50), production could be depleted to the point where further operation would not be economically feasible. When the reservoir is no longer capable of sustaining the geothermal operation, leases would terminate, facilities would be dismantled, and the land would be restored, insofar as practicable, to its original condition. Most of the disturbed area involved in the operation would have become well stabilized except for the actual areas used for the generation facilities, roads, or other structures or facilities. Removal of improvements would result in some additional disturbance, particularly in well and steam pipe line areas, but such disturbance would be of a temporary nature and subject to appropriate restoration. Unless the land areas occupied by production facilities were to be used for some subsequent and nonrelated purpose, they would be graded, drained, stabilized, and revegetated so that they would again become a part of the natural environment. Cuts and fills for roads would remain visible; however, the combination of restoration and natural vegetative recovery will, over time, result in a near natural setting with only contour change as evidence of prior uses. The lands would return to their former productivity or would be available for other appropriate uses.

Geothermal resource development in the Mammoth-Crowley Lake area could result in localized and regional long-term impacts on fish and wildlife and their habitat. There would be a loss of wildlife habitat in the immediate vicinity of installations, minor loss of birds from collision with electric distribution lines or electrocution, and potential danger to fish and other aquatic life from release of toxic geothermal fluids. Restriction of public access could reduce hunting and related recreational opportunities in the vicinity of installations. A change in the natural setting of lands could result in long-range effects on wildlife by rendering some lands more or less desirable for wildlife habitat purposes.

Effects on Mono Lake areas would be similar to those described for the Mammoth-Crowley Lake area except the impact and long-term effects on wildlife productivity would be less.

## 2. The Resource

By developing geothermal resource potentials, a previously unused and wasting natural resource would be tapped to help meet southern California's growing energy needs, especially the need for electric power. There also could be significant local use of geothermal fluids for space heating during the period of power production and even after such production has ceased as there would still be sufficient temperature differential for heating even though power production no longer was economically feasible.

While depletion of some of the heat within the geothermal reservoir would occur over the period of operations, no permanent adverse effect is anticipated. Over time, natural heat transfer within the earth might even return the heat content to nearly the same intensity as existed before utilization. At some time in the relatively distant future it might be possible for such

areas to again be used for power production. There also is the possibility that production could be in equilibrium with heat withdrawal and transfer with indefinite production life.

### 3. Water

The consumptive use of water resources, primarily geothermal fluids, in power generation would constitute a depletion of the gross water resources of the area. To the extent that geothermal fluids are withdrawn from the subsurface reservoir and not replaced by reinjection or natural recharge, the water so consumed would represent depletion of water in storage. However, in most instances, due to high mineral content, this would be water that otherwise probably would not be used. If subsidence should occur, the water storage capacity of the geothermal reservoir would be permanently reduced, but since such waters probably could not be used for other purposes within the foreseeable future, the reduced storage impact may not be adverse in terms of future water productivity. By-product water suitable for meeting local water demand would be beneficial since fresh water supplies are limited.

Geothermal fluids may be of sufficient purity to be used directly for other purposes after the fluid has been cooled. This could provide a source of fresh water during the period of power operation and it is possible that the wells could continue to be used even after power production has ended.

Under the proposed controls for waste disposal at Mono-Long Valley, degradation of surface and fresh ground waters is not expected to be significant, especially in a long-term sense. Mishaps or accidents may have short-term impacts that, depending upon the volume and nature of discharge involved, could be serious, particularly on City of Los Angeles water supplies or aquatic resources.

### 4. Land

Land uses during the period of production operations would be changed to industrial operations from fish and wildlife habitat, recreation, grazing, and timber. However, many such uses could continue on a reduced compatible basis. Wells, pipelines, power plants, by-product facilities, and power transmission facilities could dominate local areas. Public access in the vicinity of such facilities would have to be restricted to protect public safety and the facilities. Development and production of geothermal resources generally are not expected to have lasting or inhibiting effects on the use of the land after geothermal operations have been concluded and the facilities have been removed.

Should geothermal production result in land subsidence, which is an irreversible process, the subsidence would constitute a long-term effect on the land resources. Such subsidence would not significantly affect use of the land in most areas in the Mono-Long Valley KGRA because of the low population density and scarcity of engineering works.

Producing wells, surface pipelines, power plants, cooling towers, and access roads will have an adverse visual impact where they are visible to recreationists and the traveling public. The existence of such facilities could reduce the availability of land for camping, hunting, and other recreational activities. Installation of facilities could damage or destroy significant archeological values.

Timber management and production programs on national forest lands could be curtailed as a result of geothermal development. Removal of timber for roads, pipelines, production facilities, and power transmission lines will take such lands out of timber production during the life of such uses. While the timber cut would be salvaged, future production would not occur until geothermal operations ceased and the areas were restored. There could be islands of timber within the developed area that would remain but would not be available for harvest. Some part of this timber probably would be lost through natural mortality and the remaining stand could not be harvested until the geothermal improvements were removed. As much as 30 to 100 acres might be involved for each developed site, but proper planning should mitigate the short- and long-term impacts on timber resources.

## 5. Fish and Wildlife

Geothermal resource development could result in localized and even regional adverse impacts on fish and wildlife and their habitat. There could be a loss of wildlife habitat in the immediate vicinity of installations, minor loss of birds from collision with and/or electrocution on electric distribution lines, and potential danger to fish and other aquatic life from toxic fluids in the water. A change in the natural setting of lands could result in long-range effects on wildlife by rendering some lands more or less desirable for wildlife habitat purposes. Wildlife values probably would reestablish themselves as soon as the operations are terminated. In some instances they may even benefit from this use.

The removal of vegetation for roads and for production facilities could reduce the food source for both wildlife and domestic livestock. Grazing permittees using public lands impacted by such development could suffer some economic loss from the reduction of carrying capacity due to such clearing and the fencing of wellheads or other structures. However, continued grazing use should be compatible with geothermal development. In some instances the new access and revegetation measures actually may enhance wildlife habitat and range uses. Once production has ceased, the areas would be restored and uses could return to predevelopment status.

The principal ecological factor in the Mono Lake area which could be adversely affected over the long term is the food chain relationship between shore birds and fly larvae and brine shrimp. Because of its size and high mineral content, the lake probably would not be affected by accidental discharges of geothermal fluids. In fact, it may be found that geothermal fluids may be of better quality than existing lake waters which

will continue to deteriorate as the lake recedes as a result of the diversion of fresh water to Crowley Lake. As previously indicated, there could be benefit to discharge of geothermal waste waters to Mono Lake if they would not impair overall long-term water quality as the annual net loss would be reduced. A reduction of food organisms resulting from geothermal impacts or continuation in the increase of salinity due to water diversions could upset the ecological balance for bird populations in this area and in whatever other areas they select as an alternate habitat.

The ecology of the Mono Lake shore areas mainly involves the relationship between vegetation and climate and the dependence of small rodents and reptiles upon vegetation for food and cover. These relationships would suffer only minor adverse impacts from geothermal resources exploration and development since these animals could move to adjacent land. This shift would involve relatively few animals, due to their limited numbers, and would cause minor adverse impacts upon neighboring wildlife populations in terms of food competition and living space requirements. Some overall population decline would result as habitat/wildlife population balance is achieved.

The interrelationship among the various environmental components in the Mammoth-Crowley Lake "grandfather" and adjacent lands is more complex, though not necessarily more fragile than in the Mono Lake Basin. The cumulative and long-term impacts from geothermal activities could cause a greater variety of ecological impacts due primarily to the larger number of plant and animal species which exist in the area. Thus, the potential for long-term impairment of the food cycle is greater. The wildlife in forested portions depend to a large degree upon trees and other vegetation for cover during daylight hours to escape predators, including man. Disturbance of forested lands could cause deer, other mammals, and birds to crowd into adjacent areas where competition for food, cover, and nesting sites will increase and where they can be hunted more intensively. However, habitat/wildlife balances should be achieved with nominal long-term impacts. Upon completion of geothermal operations, restored areas could provide equal or better habitat than now exists.

## 6. Economic and Social

Geothermal development requires substantial investment in drilling wells and construction of roads, pipelines, power and by-product plants, and transmission lines. Such investments result in an increased tax base for the area of development. However, the labor-intensive phase is short term, occurring primarily during field development, and would not result in significant changes in population distribution. The economic benefits probably would be more in the nature of transfer benefits as a corresponding power generation capacity would have to be developed elsewhere if the geothermal resources were not developed.

There could be aesthetic or social impacts in terms of increased noise levels, odors, additional traffic, etc. even though all of the environmental

stipulations of the permits are met. These would be minor but objectionable in terms of pre-operational conditions. Since such operations could continue for a period of 25 to 50 years, they would exist during most of the lifetime of local residents or users of these areas.

Another factor of particular significance to the Paiute people living in or adjacent to the area is the availability of pinyon trees, the source of pinyon nuts which are of great value to these people. No serious impact is expected as harvesting could continue as a compatible use relative to geothermal development and operations.

G. ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION SHOULD IT BE IMPLEMENTED

Development of the geothermal resources of the Mono Lake-Mammoth-Crowley Lake area would be mainly for electrical power production, space heating, and possibly water resources. The thermal energy stored in the geothermal fluids presumably would be extracted at a rate greater than the natural terrestrial heat flow. Although the geothermal source will continue indefinitely, the use of the stored energy is considered a depletable resource over the short term.

The recharge mechanism of geothermal reservoirs of the area is presumed to be rainfall on the drainage basins tributary to the area. Thus, water evaporated in geothermal production should be considered as a water consumption chargeable to the area. However, as the water is renewable from rainfall, this charge is not irretrievable.

Compaction that may occur as a result of geothermal production is irretrievable in the sense that it is an irreversible process. Loss of porosity is a commitment of a resource because this is the storage volume for the heat-conducting fluid.

The capital and labor required for the geothermal development represent an irretrievable commitment of those resources because installations would have little salvage value when the geothermal resources are exhausted.

Areas of natural vegetation will be altered or cleared due to construction of facilities required for development and use of geothermal resources. Upon termination of production, all such areas are to be restored to as near a natural condition as is feasible but complete reversion to the pre-development conditions may not be possible. The impacts could be either adverse or beneficial, depending upon the nature of subsequent uses of the area.

Changes in the thermal regime of the Hot Creek system could occur as a result of geothermal development. This could have irreversible impacts upon that ecosystem. Subsidence of seismic activity could result in irreversible or irretrievable land, resource, and environmental impacts.

Normal land uses of the area such as recreation, timber production, livestock grazing, and hunting would be affected during the period of operations, but such uses could return to predevelopment levels after production stops and the areas are restored. The restrictions on use of leased lands and related impacts on adjacent lands could alter use patterns which could result in overuse of other areas. However, all such impacts probably would be limited to the production life of the geothermal development.

## H. ALTERNATIVES TO THE PROPOSED ACTION

Alternatives are discussed in detail in Volume I, Chapter IV, of this impact statement. Such information will not be repeated here except to the extent needed for consideration of such alternatives as they relate to the "grandfather" area leasing proposed within the Mono-Long Valley KGRA. The Electrical energy potential of the KGRA has been estimated to be in the range of 1,750 Mw but the amount that may be developed within the proposed lease areas cannot be determined until further exploration and testing discloses the extent to which geothermal reservoirs may be suited to economic power production. In terms of alternative sources of electric power, the projected potential would be equivalent to one large fossil fuel or one nuclear power plant. The environmental impacts of alternative electrical energy sources are discussed in detail in Volume I, Chapter IV, Section 4. The alternatives discussed here primarily relate to alternative timing and leasing plans for this KGRA.

### 1. No Leasing

Under this alternative, no geothermal leases would be issued for Federal lands in the Mono-Long Valley KGRA. Since there would be no exploration, test drilling, or production development, there would be no direct environmental impacts since the status quo, insofar as geothermal resources are concerned, would be maintained. However, there could be other uses of these lands for recreation, grazing, and timber production which could have adverse impacts. Alternative power sources would have to be developed within or external to the area to meet growing power needs. Additional transmission lines would be required to bring such power to the area and to distribute it to use areas. The overall total system environmental impacts of meeting local area power needs from external sources could be greater than those associated with geothermal development.

Under this alternative there probably would be no development of geothermal resources in the Mono-Long Valley KGRA since most of the land is in Federal ownership. Except for the land beneath Mono Lake, most of the State and privately owned lands are in small isolated tracts. If any of these non-Federal lands were developed for geothermal energy production, there could be environmental impacts on adjacent Federal lands similar to those described in this environmental statement.

Persons qualified to convert valid leases or permits under the Minerals Leasing Act of February 25, 1920, or to existing mining claims located on or prior to September 7, 1965, would not be permitted to convert such leases or permits or claims to geothermal leases covering the same lands as provided by Section 4(a) of the Geothermal Steam Act. This would result in denial of these so-called "grandfather rights." One of the purposes of the proposed leasing action was to permit such rights to be exercised.

Other possible adverse impacts that could result from no leasing in the Mono-Long Valley KGRA could be power shortages in the Mammoth recreation

areas. Power failures during the winter ski season could result in skiers being stranded on lifts or on upper slopes and human safety could be of concern. Power lines bringing power in over considerable distance from other areas could have less reliability than internal systems using locally generated power. The potential use of geothermal fluids as a heat source to replace other forms of fuel or electrical energy for space heating would be foregone. Such use could have environmental advantages as it would eliminate the environmental impacts associated with the total systems required to provide the alternative heating sources. A potentially significant source of State and local tax revenue would be foregone.

## 2. Lease Only Areas of Lowest Environmental Sensitivity Within the "Grandfather" Lands

The potential for adverse environmental impacts varies considerable within the "grandfather" areas, particularly the Mammoth-Crowley Lake area. The joint Forest Service/Mono County planning effort for the southern portion of Mono County includes the development of visual quality and environmental sensitivity classifications. The current status of this effort is reflected in the Summary Sensitivity/Capability map and the Visual Quality Standards map discussed previously in the environmental statement for the Mono-Long Valley KGRA.

It is difficult to evaluate the impact of this alternative on the potential for geothermal resource development as there may be no correlation between the location of the prime geothermal reservoirs and the surface conditions. If initial leasing were confined to the areas of least environmental impact, geothermal exploration and development could be undertaken, but at a smaller scale which would be more in the nature of a pilot program. Environmental impacts would be minimized. Knowledge gained from the initial leasing and development could be applied at a later date to the development of geothermal resources of the lands in more environmentally sensitive areas.

Under this alternative, persons entitled to "grandfather" conversion rights would not be treated equally as some would be permitted to exercise such rights and others would be denied the opportunity of obtaining a geothermal lease until such time as a decision was made to permit development in other portions of the "grandfather" area.

While this alternative could result in less power production from these areas, it still might provide a source of power for local demand. Environmental impacts are a matter of degree as no leases will be issued unless development can be accomplished in an environmentally acceptable manner. In most instances, there should not be a significant difference in impact throughout the "grandfather" areas since appropriate environmental protection provisions would be included in all leases and related GRO orders.

### 3. Defer Issuance of Leases in the Mammoth-Crowley Lake Area Until Completion of the Monoplan for Mammoth

This joint Forest Service/Mono County study and plan is expected to be completed in 1974. The first two phases of the planning effort are finished and much of the information has been used in this environmental assessment. An environmental inventory and baseline report has been prepared. Preliminary social and economic studies have been completed and tentative land use alternatives have been developed and proposed. Such alternatives include a "no growth" consideration.

The Forest Service has delayed approval of a proposed realignment of State Highway 203, the proposed Casa Diablo powerline right-of-way, and several proposed ski area developments until completion of the Monoplan. One of the reasons for delaying action is that such development could be growth inducing. Geothermal development also could have a growth inducing effect. If geothermal leasing in the Mammoth-Crowley Lake area should take place prior to completion of the Monoplan, the option of adopting a "no growth" alternative would be compromised.

Under this alternative, no leases would be issued in the Mammoth-Crowley Lake "grandfather" area until after the Monoplan is completed and decisions are made relative to area development, land uses, etc. Leasing probably would be delayed by one or two years as a minimum and, depending upon how leasing was to be coordinated with other considerations of the plan, further delay or even no leasing could result. The environmental impacts would be generally in direct relationship to the area leased and developed. A delay of one or two years probably would have no significant impact on future power production but a reduction in area could reduce such production. There could be overall environmental and other advantages since geothermal development would be more fully coordinated within the total plan for the area which is dominated by national forest lands. Maximum harmony could be maintained with the overall resource and environmental values of the area, with the needs and desires of both local citizens and the recreational users of the area, and other related actions such as highways, major power transmission lines, etc.

Here again, evaluation of the difference in environmental impacts involves a matter of degree since no leases will be issued unless the geothermal resources can be developed in an environmentally acceptable manner. There is high probability that there might not be a significant difference in the area leased and developed under leasing as proposed herein and that which would occur under the Monoplan alternative. In view of the limited time delay involved, there could be environmental and other advantages to this option.

Under this option, the "grandfather" lands in the Mono Lake area would be available for leasing and development without further delay.

#### 4. Exclude or Defer Leasing of National Forest Lands

Under this alternative, only those lands administered by the Department of the Interior would be leased. These could include the Mono Lake and that portion of the Mammoth-Crowley Lake "grandfather" lands which are outside of the Inyo National Forest. There could be various options within this alternative such as were discussed in preceding alternative sections.

This alternative would allow for leasing and development at Mono Lake and for a portion of the Mammoth-Crowley Lake "grandfather" areas. Persons having "grandfather" rights would not be equally treated since a major portion of the Mammoth-Crowley Lake area is national forest land. Environmental impacts would be reduced as a result of the smaller area involved and the distance from highest use recreation areas. The public lands that would be subject to leasing in the Mammoth-Crowley area are withdrawn for the protection of watershed supplying water to the city of Los Angeles and other cities and towns in the State of California under Public Law 71-864. This same withdrawal applies to the Mono Lake lands proposed for leasing. (See Appendix F for additional information on the nature of this withdrawal and the large map in the pocket at the end of this volume for land ownership and withdrawal area detail.)

The potential for geothermal power production would be greatly reduced until such time as a decision was made to lease national forest lands. Likewise, the potential use for space heating would be foregone. Local power needs might be met under this limited leasing program but optimum geothermal resource development probably would not be achieved. As discussed in the other alternatives, the environmental impacts would be a matter of degree depending upon the area leased and the intensity of resource development and power production.

#### 5. Defer Leasing Until New or Improved Technologies and/or Systems are Available for Geothermal Energy Production

Under this alternative, leasing might be delayed for 5 or 10 years to allow additional time for the development of new technologies or systems for geothermal power production and for environmental protection. This subject is discussed in detail in Volume 1 of this impact statement and in the appropriate sections of the Mono-Long Valley portion of the statement. Such improvements could result in production systems that achieve both more efficient use of the resource and reduced environmental impacts, primarily the potential air and water quality factors.

There will be considerable elapse of time between leasing and actual power production. Development and production in The Geysers and Imperial Valley private land areas probably will have progressed to the point where many of the new systems or controls have been developed and tested and they could be applied to Federal leases at the time development is undertaken.

Under the proposed leasing plan, no leases will be issued or operations permitted unless such can be done in an environmentally safe manner.

Accordingly, the relative environmental impacts associated with the proposed leasing and a delay of several years is a matter of degree. While some technology and systems designed for one area can be used in other areas, many of the environmental problems will differ due to the nature of the geothermal steam or liquids and the setting in which operations are to be conducted. Experience gained by development within the area could be far more valuable than that which might be obtained from operations under significantly different conditions.

A delay of this nature probably would result in the need to construct several small, or one large, fossil fuel generation facilities or a nuclear facility within or external to the area to meet local power needs and to offset the additional electrical energy supply source that would have resulted from earlier development of this resource. The impacts would be in terms of time as energy demand growth will continue and such plants probably would have to be built sooner or later.

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COMMON PLANTS FOUND IN THE MAMMOTH-CROWLEY LAKE "GRANDFATHER" AREA

<u>Pinus jeffreyi</u>	Jeffrey pine
<u>Abies concolor</u>	White fir
<u>Ceanothus velutinus</u>	Showbrush
<u>Arctostaphylos patula</u>	Greenleaf mansanita
<u>Ribes cereum</u>	Squaw currant
<u>Artemisia tridentata</u>	Sagebrush
<u>Purshia tridentata</u>	Bitterbrush
<u>Cercocarpus ledifolius</u>	Curlleaf mountain mahogany
<u>Amelanchier alnifolia</u>	Serviceberry
<u>Ceanothus cordulatus</u>	Mountain whitethorn
<u>Ribes cereum</u>	Squaw currant
<u>Quercus vaccinifolia</u>	Huckleberry oak
<u>Castanopsis sempervirens</u>	Bush chinquapin
<u>Phyllodoce breweri</u>	Mountain heather
<u>Chrysothamnus spp.</u>	Rabbitbrush
<u>Prunus Andersonii</u>	Desert peach
<u>Ceanothus Greggii</u>	Desert ceanothus
<u>Tetradymia canescens</u>	Gray horsebrush
<u>Peraphyllum ramosissimum</u>	Squaw apple
<u>Pinus monophylla</u>	Singleleaf pinyon
<u>Juniperus californica</u>	California juniper
<u>Juniperus osteosperma</u>	Utah juniper
<u>Eriogonum spp.</u>	Buckwheat
<u>Symphoricarpos longiflorus</u>	Desert snowberry
<u>Grayia spinosa</u>	Spiny hop-sage (alkaline)
<u>Haplopappus spp.</u>	Goldenbush
<u>Ephedra viridis</u>	Green ephedra
<u>Lupinus spp.</u>	Lupine
<u>Rosa spp.</u>	Wild rose
<u>Ribes spp.</u>	Gooseberry and currants
<u>Balsamorhiza sagittata</u>	Arrowleaf balsamroot
<u>Wyethia mollis</u>	Mule-ears

COMMON PLANTS OF THE MONO BASIN

Mountain Trees

Jeffrey Pine - Pinus jeffreyi  
 Whitebark Pine - P. albicaulis  
 Lodgepole Pine - P. murrayana  
 Western White Pine - P. monticola  
 Red Fir - Abies magnifica  
 White Fir - A. concolor

Western Juniper - Juniperus occidentalis  
 Mountain Hemlock - Tsuga merletiana  
 Aspen - Populus tremuloides  
 Mt. Mahogany - Cercocarpus ledifolius

Mountain Shrubs

Great Basin Sagebrush - Artemisia tridentata  
 Roth rock Sagebrush - A. rothrockii  
 Snowberry - Symphoricarpos rotundifolius  
 Snowbush - Ceanothus gregii  
 Golden Currant - Ribes aureum  
 Shrubby cinquefoil - Spiraea densiflora  
 Cream Bush - Holidiscus discolor

Wild Rose - Rosa woodsii  
 Dwarf Bilberry - Vaccinium caespitosum  
 Willows - Salix several species  
 Wild Buckwheats - Eriogonum many species  
 Mountain Heather - Phyllodoce breweri  
 Bitter Cherry - Prunus emarginata  
 Rabbitbrush - Chrysothamnus nauseosus  
 Haplopappus - Haplopappus macronema  
                   - Haplopappus suffruticosus

Mountain Wild Flowers

Meadow buttercups - Ranunculus sp.  
 Missouri Iris - Iris missouriensis  
 Shooting Stars - Dodecatheon jeffreyi  
 Monkey flowers - Minulus several sp.  
 Larkspur - Delphinium several sp.  
 Wild Onion - Allium campanulatum  
 Monkshood - Aconitum columbianum  
 Bitter root - Lewisia rediviva  
 Evening primrose - Oenothera sp.  
 Erigeron - Erigeron sp.  
 Pincushion flower - Chaenactis sp.  
 Columbine - Aquilegia sp.

Indian Paintbrush - Castilleja several sp.  
 Mt. Penstemon - Penstemon newberryi  
 Phlox - Phlox stanisburyi  
 Balsam root - Balsamorhiza sagittata  
 Phacelia - Phacelia fremontii  
 Aster - Aster sp.  
 Yarrow - Achillea lanulosa  
 Wallflower - Erysimum asperum  
 Golden Aster - Haplopappus apargiodes  
 Mt. Pennyroyal - Monardella odoratissima

Mountain Grasses & Grass-Like Plants

Sedge - Carex many species  
 Rush - Juncus several species  
 Needlegrass - Stipa several sp.  
 Squirreltail - Sitanion hustrix  
 Melic grass - Melica stricta  
 Junegrass - Koeleria cristata  
 Meadow Barley - Hordeum modosum

Mt. Bromegrass - Bromus carinatus  
 Alpine timothy - Phleum alpinum  
 Bluegrass - Poa several species  
 Mt. Redtop - Agrostis variabilis  
 Ryegrass - Elymus several species  
 Cheatgrass (Downey chess) - Bromus tector  
 Oatgrass - Danthonia intermedia

## APPENDIX B (cont)

### Desert Trees

Single-leaf Pinyon - Pinus monophylla  
Buffalo Berry - Shepherdia argentea  
Cottonwood - Populus angustifolia

Utah Juniper - Juniperus osteosperma  
Willow - Salix several species

### Desert Shrubs

Great Basin Sagebrush - Artemisia treidenata  
Black Sagebrush - Artemisia nova  
Rubber Rabbitbrush - Chrysothamnus  
nauseosus (two sub-species)  
Sticky Rabbitbrush - C. viscidiflorus  
Black Greasewood - Sarcobatus vermiculatus  
Saltbrush - Atriplex canescens  
Spiny Saltbrush - A. confertifolia  
Winter Fat-Erotia lanata  
Bitterbrush - Purshia tridentata  
Spiny Phlox - Phlox stansburyi

Granite Gilia - Leptodactylon pungens  
Wild Currant - Ribes cereum  
Wild Rose - Rosa woodsii  
Silver Sagebrush - Artemisia cana  
Horsebrush - Tetradymia glabrata  
Horsebrush - T. canescens  
Desert Sweet - Chamaebatiaria mill-  
efolium  
Desert Peach - Prunus andersonii  
Mormon Tea - Ephedra viridis  
Hop Sage - Graya spinosa

### Desert Wild Flowers

Desert Primrose - Oenothera deltoides  
Lupine - Lupinus several species  
Paint-Brush - Castilleja chromosa  
Wallflower - Erysimum capitatum  
Yellow throats - Phacelia fremontii  
Monkey Flower - Mimulus bigelovii  
Evening Primrose - Oenothera brevipes  
Hooker Evening - Primrose - O. Hookeri  
Locoweed - Astragalus several species  
Sand verbena - Abronia villosa  
Hulsea - Hulsea vestita  
Penstemon - Penstemon speciosus

Wild-Heliotrope - Phacelia distans  
Gilia - Gilia several species  
Pincushion flower - Chaenactis  
stevioides  
Mariposa Lily - Calochortus nuttallii  
Prickly Poppy - Argemone corymbosa  
Beaver Tail Cactus - Opuntia basilaris  
Heron (Storks) Bill - Erodium cictarium  
Wild Onion - Allium several species  
Pussy Paws - Calyptridium umbellatum  
Wild Tobacco - Nicotiana attenuata

### Desert Grasses & Grass-Like Plants

Indian Ricegrass - Oryzopsis hymenoides  
Kentucky Bluegrass - Poa pratensis  
Nevada Bluegrass - P. nevadensis  
Needle & Thread Grass - Stipa comata  
Beardless Wild-Rye - Elymus triticoides  
Ashy Wild-Rye - E. cinereus  
Sedge - Carex many species

Saltgrass - Distichlis stricta  
Meadow Barley - Hordium brachyantherum  
Rush - Juncus several species  
California Bromegrass - Bromus carinatu  
Thurber's Needlegrass - Stipa  
thurberiana  
Squirreltail grass - Sitanion hystrix

PARTIAL LIST OF THE AVIFAUNA THAT INHABITS THE MAMMOTH-CROWLEY LAKE

GEOHERMAL STEAM "GRANDFATHER" AREA. THIS LIST INCLUDES BOTH THE  
RESIDENT AND MIGRANT SPECIES.

WATERFOWL, SHOREBIRDS

Canada goose  
Snow goose  
White pelican  
California gull  
Lesser yellow legs  
Wilson phalarope  
Willit  
Common snipe  
American coot  
American avocet  
Black-necked stilt  
Eared grebe  
Western grebe  
Great blue heron  
Black tern  
Dunlin  
Long billed dowitcher  
Western sandpiper  
Spotted sandpiper  
Pintail  
Green winged teal  
Blue winged teal  
Cinnamon teal  
Mallard  
Red head  
Ruddy duck  
Shovler  
Gadwall  
Whistling swan

SONGBIRDS

Western flycatcher  
Western wood peewee  
Horned lark  
Bank swallow  
Cliff swallow  
Raven  
Bewicks wren  
Nighthawk  
Sagethrasher  
Robin  
Audubons warbler  
Western meadow lark  
Yellow headed black-bird  
Red-winged black-bird  
Brewers blackbird  
Brown headed cowbird  
Green tailed towhee  
Rufous sided towhee  
Vesper sparrow  
Sage sparrow  
Brewers sparrow  
Song sparrow  
Black billed magpie  
Mountain blue bird  
Logger head shrike  
Stillars jay  
Pinyon jay  
Mountain chickadee  
White breasted nuthatch  
Red breasted nuthatch  
Brown creeper  
Canyon wren  
Rock wren  
Startling  
Warbling vireo  
Wilsons warbler  
Western tanager  
Cassins finch  
Oregon jimio  
Chipping sparrow  
Hermit warbler  
Fox sparrow  
Song sparrow  
Violet green swallow

RAPTORS

Red tailed hawk  
Marsh hawk  
Sparrow hawk  
Coopers hawk  
Prairie falcon  
Rough legged hawk  
Swansons hawk  
Great horned owl  
Long eared owl  
Burrowing owl  
Saw-whet owl  
Screech owl  
Golden Eagle  
Bald Eagle

GAMEBIRDS

Mountain quail  
Blue grouse  
Mourning dove  
Sage grouse  
Band-tailed pigeon

MONO APPENDIX D

MAMMALS THAT INHABIT THE MAMMOTH-CROWLEY LAKE AND MONO LAKE

"GRANDFATHER" GEOTHERMAL STEAM AREAS

1/

<u>Common Name</u>	<u>Generic Name</u>	<u>Habitat Name</u>
Merriam shrew	<u>Sorex merriami</u>	S-PJ-Co
Trowbridge shrew	<u>Sores trowbridgii</u>	Me
Vagrant shrew	<u>Sorex vagrans</u>	S
Broad-handed mole	<u>Scapenus latimanus</u>	Me
Black-tailed hare	<u>Lepus californicus</u>	S-PJ-Co-Me
Nuttall cottontail	<u>Sulvilagus nuttallii</u>	S-PJ-Co
Audubon cottontail	<u>Sulvilagus audubonii</u>	Me-S
Pigmy rabbit	<u>Sulvilagus idahoensis</u>	S
Townsend ground squirrel	<u>Spermophilus townsendii</u>	S-PJ-B-Co
Belding ground squirrel	<u>Spermophilus beldingi</u>	Me-Co
Beechey ground squirrel	<u>Spermophilus beecheyi</u>	S-PJ-Co-B-Me
Sierra golden mantled ground squirrel	<u>Spermophilus lateralis</u>	Co-PJ-B
Least chipmunk	<u>Eutamias minimus</u>	S-Co
Yellow pine chipmunk	<u>Eutamias amoenus</u>	Co-B
Panamint chipmunk	<u>Eutamias panamintinus</u>	S-PJ-Co
Lodgepole chipmunk	<u>Eutamias speciosus</u>	Co
Townsend chipmunk	<u>Eutamias townsendii</u>	Me-Co
Meriam chipmunk	<u>Eutamias merriami</u>	S-PJ
Botta pocket gopher	<u>Thomomys bottae</u>	Me
Mountain pocket gopher	<u>Thomomys monticola</u>	Me-Co
Great Basin pocket mouse	<u>Perognathus parvus</u>	S-PJ
Long-tailed pocket mouse	<u>Perognathus formosus</u>	S
Panamint kangaroo rat	<u>Dipodomys panamintinus</u>	PJ-S
Merriam kangaroo rat	<u>Dipodomys merriama</u>	S
Great Basin kangaroo rat	<u>Dipodomys microps</u>	S
California mouse	<u>Peromyscus crinitus</u>	Me
Deer mouse	<u>Peromyscus maniculatus</u>	All
Brush mouse	<u>Peromyscus boylii</u>	S-B-PJ
Pinyon mouse	<u>Peromyscus truei</u>	PJ-S
Montane meadow mouse	<u>Microtus montanus</u>	Me
California meadow mouse	<u>Microtus californicus</u>	Me-Co
Sagebrush meadow mouse	<u>Lagurus curtatus</u>	S-PJ
Porcupine	<u>Erethizon dorsatum</u>	Co-PJ
Northern pocket gopher	<u>Thomomys talpoides</u>	Me
Coyote	<u>Canis latrans</u>	All
Black bear	<u>Euarctos americanus</u>	Co
Ringtail cat	<u>Bassariscus astutus</u>	Co
Raccoon	<u>Procyon lotor</u>	Me (riparian)
Marten	<u>Martes americana</u>	Co
Fisher	<u>Martes pennanti</u>	Co
Long-tailed weasel	<u>Martes frenata</u>	All
Mink	<u>Mustela vison</u>	Me (riparian)

# APPENDIX D (cont)

Badger	<u>Taxidae taxus</u>	All
Spotted skunk	<u>Spilogale putorius</u>	S-Me-Co
Striped skunk	<u>Mephitis mephitis</u>	S-Me-Co
Mountain lion	<u>Felis concolor</u>	All
Bobcat	<u>Lynx rufus</u>	All
California mule deer	<u>Odocoileus hemionus calif-ornicus</u>	All

1/ Habitat types are represented by the following symbols: S - Sagebrush; PJ - Pinyon Juniper; Co - Conifer; Me - Meadow; Riparian - grassland; and B - browse.

## REPTILES AND AMPHIBIANS THAT INHABIT THE MAMMOTH-CROWLEY LAKE GEOTHERMAL STEAM "GRANDFATHER" AREA

- Great Basin spadefoot toad (Scaphiopus intermontanus)
- Western toad (Bufo boreas)
- Mountain yellow-legged frog (Rana muscosa)
- Great Basin fence lizard (Scalopus occidentalis)
- Sagebrush lizard (Scalopus graciosus)
- Pacific rubber bea (Charina bottae)
- Red racer (Masticophis falgellum)
- Striped whipsnake (Masticophis taeniatus)
- Great Basin gopher snake (Pitnophis melanoleucus)
- Sierra garter snake (Thamnophis couchi)
- Great Basin rattlesnake (Crotalus viridis)

# MONO APPENDIX E

## BIRDS OBSERVED IN THE MONO LAKE "GRANDFATHER" AREA

Western Grebe	Brewers blackbird
Horned Grebe	American avocet
Eared Grebe	Black-necked stilt
Pied-billed grebe	Great horned owl
White Pelican	Violet green swallow
Double-crested Cormarant	White-throated swift
Blue Heron	Nighthawk
Whistling Swan	Golden eagle
Lesser Scaup	Red-tailed hawk
Golden Eye	Rough-legged hawk
Ruddy Duck	Sparrow hawk
Coot	Marsh hawk
Black bellied plover	Prairie falcon
Whimbrel	Red-winged black bird
Spotted Sandpiper	Yellow rail
Snipe	Sage thrasher
Western Sandpiper	Brewers sparrow
Lease Sandpiper	Sage sparrow
Western Phalarope	Raven
Northern Phalarope	Northern shrike
Ring-billed gull	
California gull	
Sabine gull	
Black tern	

March 4, 1931.  
[H. R. 11969.]  
[Public, No. 864.]

CHAP. 517.—An Act Withdrawing certain public lands from settlement, location, filing, entry, or disposal under the land laws of the United States for the protection of the watershed supplying water to the city of Los Angeles and other cities and towns in the State of California, and for other purposes.

Public lands.  
Withdrawal of, for  
protecting, water supply  
of Los Angeles, etc.,  
Calif.

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,* That the following-described public lands are hereby withdrawn from settlement, location, filing, entry or disposal under the land laws of the United States for the purpose of protecting the watersheds now or hereafter supplying water to the city of Los Angeles and other cities and towns in the State of California, to wit:

Proviso.  
Existing valid rights  
not affected.

SEC. 2. That all lands withdrawn under the provisions of this Act shall at all times be open to exploration, discovery, occupation, and purchase permit or lease under the mining or mineral leasing laws of the United States so far as same apply to minerals in said land, and to the acquisition of rights or easements under laws of the United States applicable for rights of way for railroads, highways, reservoirs, ditches, canals, electrical power plants, and transmission lines, telegraph and telephone lines, or other rights of way authorized to be granted under any of the laws of the United States: *Provided*, That nothing in this Act contained shall be construed as affecting any existing valid water right or lawful homestead or desert-land claim heretofore initiated, or upon which any valid settlement has been made and is at the date of this Act being maintained and perfected pursuant to law, but the terms of this proviso shall not continue to apply to any particular tract of land unless the entryman or settler shall continue to comply with the law under which the entry or settlement was made, and upon the extinguishment of any such claim by cancellation, relinquishment, or otherwise, this withdrawal shall immediately apply to and become effective upon such land: *And provided further*, That nothing herein contained shall be construed as affecting the use or occupation of any of said withdrawn lands for recreational or grazing purposes under such rules and regulations as the Secretary of the Interior may deem necessary to conserve the natural forage resources of the area.

Use of lands for  
other purposes.

Approved, March 4, 1931.

# IMPERIAL VALLEY KNOWN GEOTHERMAL RESOURCE AREAS

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## IMPERIAL VALLEY

### KNOWN GEOTHERMAL RESOURCE AREAS

#### A. DESCRIPTION OF THE PROPOSAL

The proposed action is the leasing by competitive bidding under provisions of the Geothermal Steam Act of 1970 of the federally owned geothermal resources within the Salton Sea, Glamis, Dunes, and East Mesa Known Geothermal Resource Areas (KGRAs), Imperial Valley, California, as shown in Figure I-1 and the map enclosed in the pocket at the end of this volume. The Brawley and Heber KGRAs contain no Federal lands and therefore are not subject to this leasing proposal.

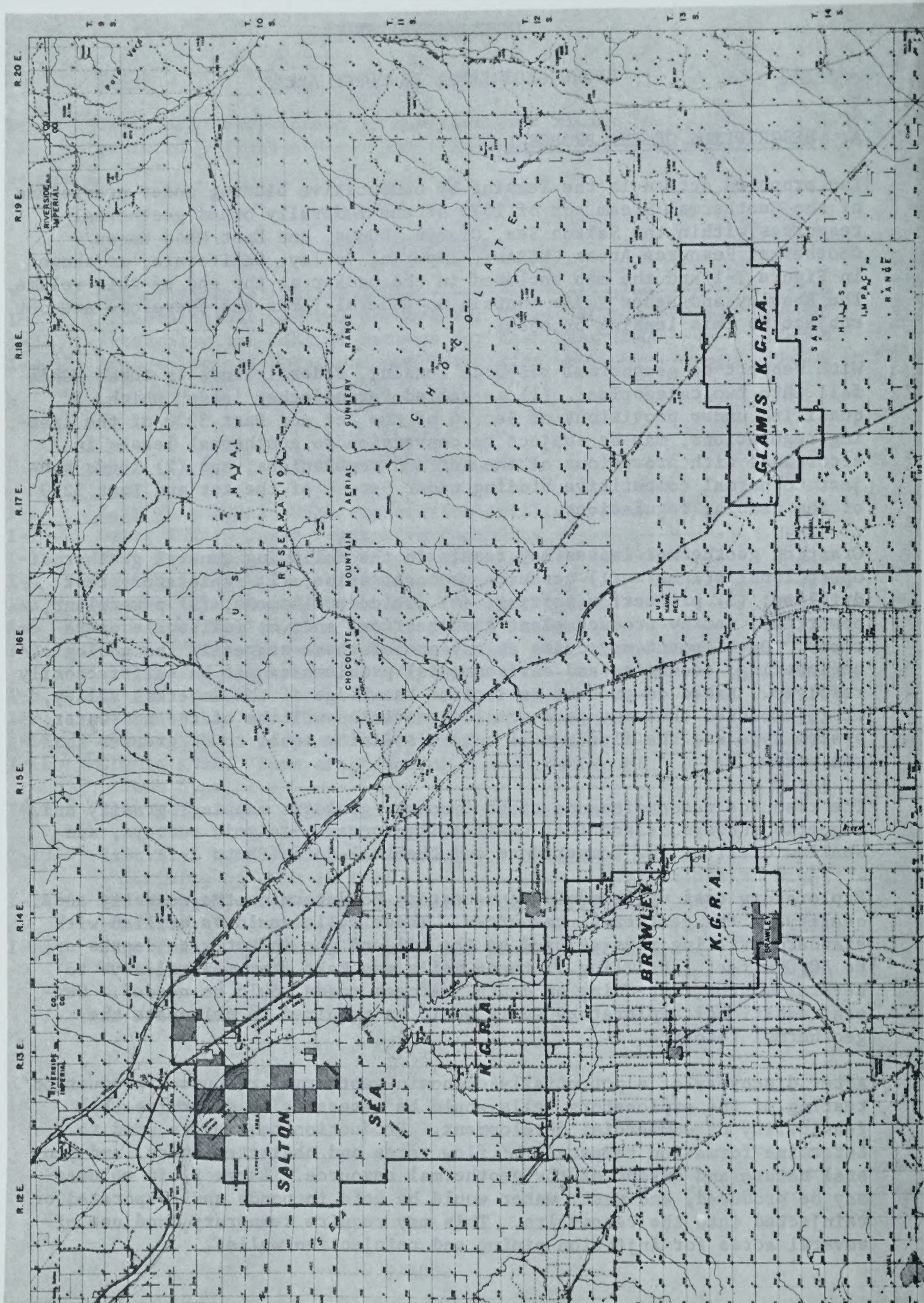
With respect to geothermal resource leasing, Federal lands in these KGRAs fall into two categories: (1) so-called "grandfather lands" which, if qualified under provisions of Sec. 4 of the Act and Part 3230 of the leasing regulations, may be subject to conversion to geothermal leases in accordance with provisions of the Act and regulations; and (2) lands subject to normal competitive bidding under Sec. 4 of the Act and Part 3220 of the leasing regulations.

Granting geothermal leases may result in the following general geothermal operational stages: (1) resource reconnaissance; (2) exploratory test drilling; (3) production testing; (4) field development; (5) powerplant, powerline, and by-product plant construction; and (6) full-scale operations. Development may cease at any one of these stages if the geologic, engineering, economic, and environmental problems cannot be satisfactorily resolved. Based on present geological knowledge of the Imperial Valley, it is expected that any geothermal discoveries will be of the hot-water system type and the fluids will have a salinity equal to or greater than sea water.

The resource reconnaissance stage involves geologic mapping, gravity and magnetic surveys, electrical resistivity surveys, seismic surveys, and shallow drilling for temperature and chemical data (Photo I-1).

Exploratory test wells would be necessary to determine the quantity and quality of the geothermal resources. These wells would be drilled with standard drilling rigs as used by the oil and gas industry to depths up to 10,000 feet. Drilling of these wells may take from several days to several months, depending on depth. Access roads would be needed. Several additional exploratory wells would be required to delineate the geothermal resource.

After discovery of a potentially economic geothermal resource, production testing of the exploratory wells would be necessary to determine the feasibility of commercial development. Production testing is used to determine formation temperature, flow rates and characteristics, and general nature and extent of the geothermal resource. Large fluid volumes may be produced, and waste water would be held in ponds and evaporated or reinjected into the reservoirs. This may require temporary land use of several acres for injection piping and reinjection wells.



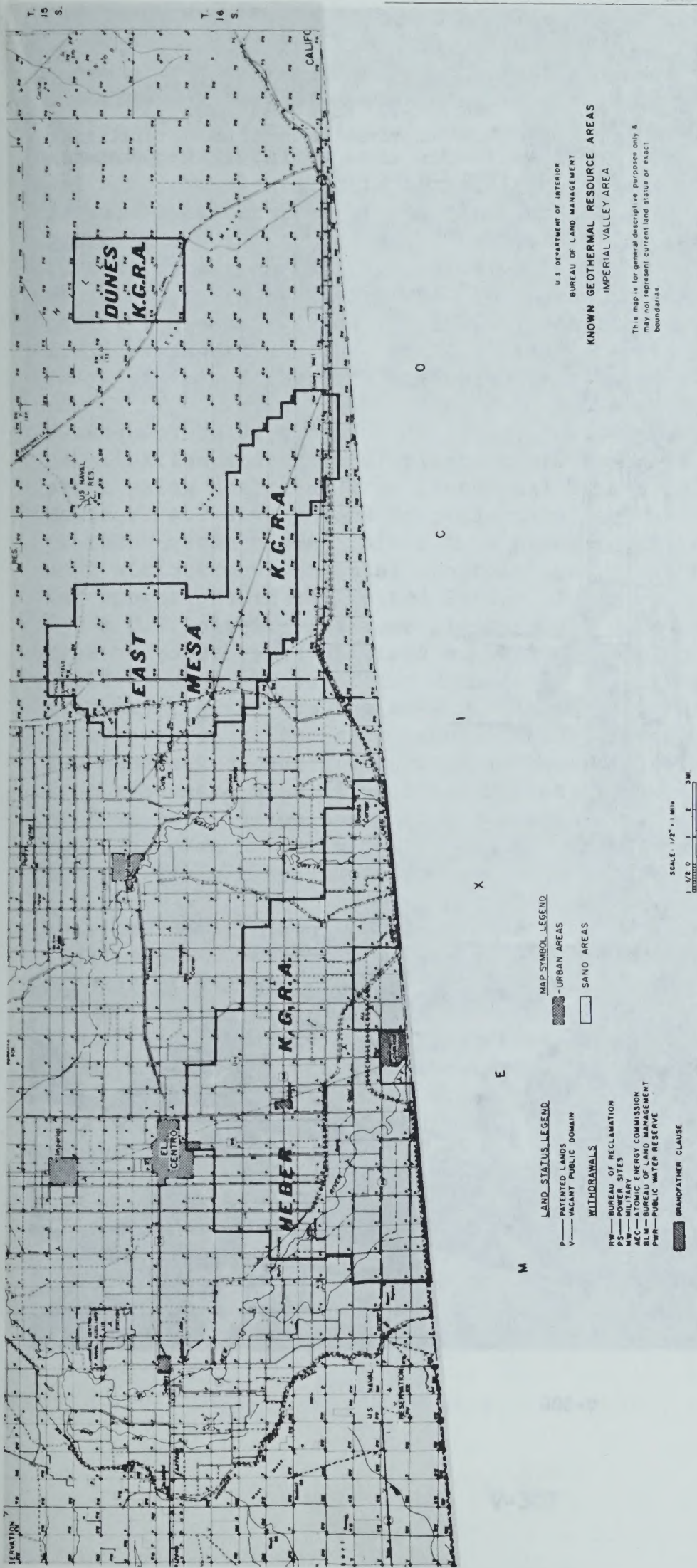
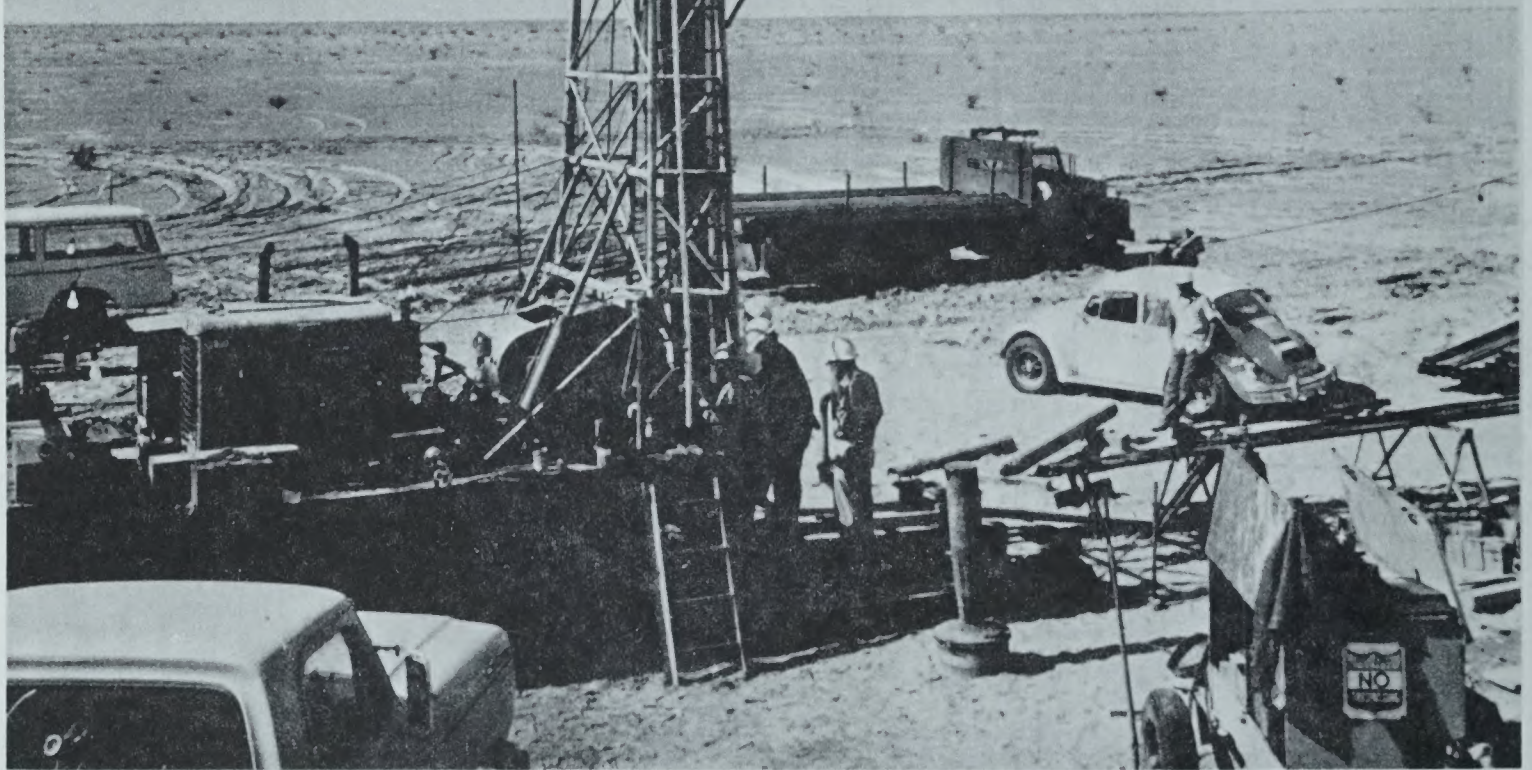


Figure I-1

Photo I-1. East Mesa KGRA.  
USBR exploration drillings; drilling  
shallow (less than 1500') temperature  
monitoring hole.



Upon completion of production testing, additional development wells would have to be drilled to furnish steam and/or hot water to the electrical generating, desalination, or chemical plants involved. Spacing of wells may vary considerably, depending on the geology and productive characteristics of the reservoir and the power cycles utilized. Additional road networks, drill sites, and pipelines to move the produced fluids from the wells to the plants would be required. Roads generally would be semi-permanent in order to provide continued access to wells. Drill sites generally would occupy about 2 acres. This area would be greatly reduced in size once the drilling equipment is moved out; the completed wellhead may occupy no more than a 20' x 20' area. Pipelines would be of moderate to large diameter (about 6" to 24"), depending on the kind and volume of fluid transported. They would be insulated to lessen heat loss. Surface temperatures of the insulated pipelines would be warm to the touch.

Subsequent to development drilling, powerplants, powerlines, and possible desalination and chemical plants would be built. The only generating plant using hot steam from geothermal brines is located at Cerro Prieto, Mexico. All discussions of production are speculative and generally refer to the Mexican plant. Since this plant is operated by the Mexican government without environmental controls equivalent to what will be required for operations in the United States, it is not a fully comparable model for a U.S. plant. The powerplants would vary in size depending on the type of power cycle utilized but will generally not exceed a 40' x 80' building size. Most of the methods of utilizing the geothermal resource also may require cooling towers. About 80 percent of the cooling water is evaporated to the air. Approximately 50 acre-feet of water per year per megawatt of power generated is required. This water source may be from condensed steam from the turbines, the water produced from the wells, or from outside sources. If economically justifiable, desalination and/or chemical plants may be built. In appearance these plants would resemble natural gas plants and refineries of moderate size.

Full-scale operations would involve surface occupation in the form of roads, wells, powerplants, powerlines, and by-product plant sites. By-product plants would probably be consolidated with powerplants. Based on existing developed geothermal areas and techniques, plants of a capacity of approximately 100 megawatts would be built, each plant being supplied by wells draining about one square mile. Noncondensable gases may be vented or be emitted from cooling towers. Geothermal fluids would be reinjected. (Refer to Volume I, Chapter I, for additional description of the proposal.)

## B. DESCRIPTION OF THE ENVIRONMENT

### 1. Location and Climate

The Salton Sea, Glamis, Dunes, and East Mesa KGRA's are located in Southeastern California in Imperial County. These areas lie approximately 100 miles east of San Diego.

These KGRA's are located in a closed drainage basin with all drainage into the Salton Sea. The area is rather flat, arid, and surrounded by ragged mountains.

Elevations vary from several thousand feet in the surrounding mountains to a low of 278 feet below sea level in the Salton Sea. The area has a characteristic desert climate, with hot, dry summers and mild winters. Temperatures of over 100° typically occur more than 100 days each year, and precipitation averages less than 3 inches annually, occurring largely in the fall and winter months. There are about 12 days of frost each year. There is little fog, few thunderstorms, and winds vary from light to strong, predominantly coming from the west and northwest. Considerable smog is generated locally from burning stubble field and smog drifts in from the Los Angeles area, when air currents flow in a southwesterly direction.

The Salton Sea is about 36 miles long and 12 miles wide. Topography in the vicinity of the Sea is flat. The Sea is shallow, ranging from about -278 mean sea level (msl) at its deepest point to a present water surface elevation of about -232 msl. There are 100 miles of shoreline.

The Salton Sea was formed when record flood crests of the Colorado River spilled into the Imperial Valley in 1905-1907. Since then the Sea has been maintained by natural runoff and irrigation return flows. Natural drainage is principally through the Alamo and New Rivers and artificial drainage occurs through numerous irrigation canals and drains that traverse the irrigated area.

### 2. Geology

The geology of all four KGRA's is similar. Imperial Valley is in a sediment-filled, northwesterly trending, structural trough called the Salton Trough. The entire depression is filled primarily by deltaric deposits of the Colorado River, but included are some lakebed and marine deposits. The valley is bordered on the northeast and southwest by mountains composed of crystalline rocks and marine and non-marine sedimentary rocks.

The Gulf of California marks the intersection of the East Pacific Rise with the North American continent. A higher than normal geothermal gradient is associated with the East Pacific Rise and extends north throughout the length of a Salton Trough. This high heat flow, locally

4 to 10 times normal, is manifested at the surface in Imperial Valley by two areas of volcanic rocks of quaternary age and several areas of hot-spring activity. High geothermal gradients in water-saturated sediments, of the Salton Trough offer the potential for development of extensive geothermal resources.

The lower part of Imperial Valley during Pleistocene time was occupied by lakes. The old shorelines of Lake Cahuilla are about 50 feet above sea level. Today the cultivated agricultural land is entirely within the former shorelines of the prehistoric lake. Soils formed on the lake sediments are higher in clay and silt than alluvial soils found on higher lands to the east and west.

The Clastic sediments filling the Salton Trough are estimated to be as much as 20,000 feet thick. These sediments can be grouped in three broad categories, from the surface down: (1) a sequence of mostly non-marine deltaic deposits of late Tertiary and Quaternary age derived mainly from the Colorado River; (2) a marine unit (Imperial Formation) of late Tertiary age; and, (3) a lower sequence, chiefly non-marine sedimentary rocks of early to middle Tertiary age, but including some volcanic rock and minor marine sediments.

On the east side of the Salton Sea volcanic rock which forms a row of small conical buttes composed of rhyolitic obsidian, scoria, and pumice indicate that the sedimentary column has been pierced by volcanic action.

No other volcanic rocks have been found in Imperial Valley. Volcanic rocks are also present in the Cerro Prieto, Mexico area.

The Imperial Valley is traversed by at least four major active strike-slip faults trending generally NW-SE, parallel to the trend of Salton Trough. Several branches of these faults have been mapped in Imperial Valley. Among the best known faults are the San Andreas, Elsinore, Imperial, and San Jacinto faults.

In addition, seismic studies of the Salton Sea area California Department of Water Resources, (Appendix G, 1970) have indicated an extremely complex faulted structural picture for the central part of the valley which has experienced 9 earthquakes which magnitudes between 6.0 and 7.1 over the last 70 years. The most notable earthquake included two destructive shocks on June 22, 1915 (magnitudes of about 6.25 Richter scale), which killed six people in the southern Imperial Valley. Another earthquake centered near El Centro on May 18, 1940 (magnitude 7.1), caused 40 miles of surface rupture on the Imperial fault and over \$6 million damage to structures in El Centro, Brawley, and Imperial. The maximum surface displacement was 19 feet.

Allen and others (1965, p. 782) have extrapolated from recurrence curves that, on the average, one earthquake of magnitude 5.3 occurs each year, one of magnitude 7.6 each hundred years and one of magnitude 8.0 every 173 years. Despite this high seismic activity, no great earthquake

(magnitude greater than 7.7) has occurred here within the historic time. Perhaps the occurrence of moderate sized earthquakes at the present rate sufficiently relieves the regional strain. Schulz and Fitch (1969) calculated that the net strain energy accumulation annually in the Imperial Valley is equal to the energy released by the fault moving 7.2 cm. The average displacement of the 1940 Imperial earthquake was about 170 cm. If the rate of strain accumulation observed from 1941 to 1954 is constant, the recurrence interval of magnitude 7 earthquakes should be about 25 years.

The seismic regime of the area is dominated by right-lateral strike-slip displacement on the San Andreas fault system. The system has two principle branches in the area: the San Andreas (Banning-Mission Creek) fault along the northeastern edge of the trough and the San Jacinto fault zone along the southwestern edge. In the Imperial Valley south of the Salton Sea, the San Jacinto fault splays into a series of left-stepping, en-echelon faults. The Imperial fault, which is regarded as the southeastern-most segment, extends from a point near Brawley south-eastward into Mexico with a length of over 50 km. There was displacement along this fault in 1940 during a magnitude 7.1 earthquake. Surficial evidence for the southeast extension of the San Andreas fault beyond the Salton Sea is intermittent. Evidence for three faults (The Calipatria, Brawley, and Holtville faults) sub-parallel to, and lying between the Imperial and Sand Hills faults south of the Salton Sea is based on geophysical data (Elders, et.al., 1972). These faults have inferred lengths of at least 30 to 40 km. The level of activity involving small to moderate earthquakes ( $M < 7.2$ ) is higher here than elsewhere along the length of the San Andreas fault. Ten earthquakes with magnitudes six or greater have occurred in the area since 1912; eight of these are associated with movement on the San Jacinto fault system (Allen and Nordquist, 1972). Seismicity maps for the period 1934 to 1969 based on the California Institute of Technology seismograph network show a fairly dense pattern of earthquake epicenters of magnitude greater than 4 in the region south of the Salton Sea. The tectonic setting of the Imperial Valley and its historical record of seismicity, indicate that an earthquake in the magnitude range 6 to 7 within or immediately adjacent to any of the five KGRA's in the Imperial Valley could occur.

Displacement along active faults in the Imperial Valley may be triggered by moderate earthquakes elsewhere in the Salton Trough. For example right-lateral displacements of 1 to 2-1/2 cm was observed over 22 to 30 km of the Imperial, Superstition Hills, and San Andreas faults at the time of the magnitude 6.4 Borrego Mountain earthquake in 1968 at distances of 45 to 70 km from the epicenter (Allen et.al., 1972).

a. Salton Sea KGRA

The San Andreas-San Hills fault passing through the northeast corner and the geophysically inferred Brawley and Calipatria faults, which transect the middle of the Salton Sea KGRA area. The Caltech catalogue indicates a relatively high level of seismicity in the southern half of the KGRA including several magnitude 5 plus earthquakes. Brune and Allen (1967) reported recording more than 75 microearthquakes per day within a radius of 24 km of a station operated on Obsidian Butte for a two-day period in January of 1966. Other sites occupied in the Imperial Valley showed less than 3 earthquakes per day.

b. Glamis KGRA

The Glamis KGRA is bisected by the inferred San Andreas-San Hills fault. According to the Caltech catalogue, seismic activity has been relatively low in this area with the exception of one epicenter for an earthquake of magnitude 5 plus located near the southern edge of the Glamis KGRA.

c. Dunes KGRA

The Dunes KGRA is located just southwest of the southeastern end of the inferred San Andreas-San Hills fault. The Caltech catalogue shows a relatively low level of seismicity in the immediate vicinity of this KGRA.

d. East Mesa KGRA

The East Mesa KGRA is between the inferred Holtville fault and the San Andreas-San Hills fault. According to the Cal Tech catalogue, seismic activity has been relatively low in this area, except for one earthquake of magnitude 5 plus located a few kilometers of the East Mesa KGRA.

### 3. Geothermal Resources Potential

Several estimates of the geothermal potential of the Salton Sea-Imperial Valley area have been made. A significant divergence of opinion exists on the extent of the resources and its projected "on line" date.

Rex (1970) estimates 1.6 to 4.8 billion acre feet of available water in the area and a power capacity of about 20,000 to 30,000 MW. Dutcher et.al.(1972) suggest recoverable water to be about 1.1 billion acre feet, of which, about 200 million acre feet are estimated to be at greater than 150°C. A recent report issued by Stanford Research Institute (1973) indicates an ultimate capacity of 3,000 MW, with less than 200 MW installed by 1985. This report is based upon the Dutcher et.al. report, which excludes the hypersaline brines of the Salton Sea geothermal area. The California Division of Oil and Gas estimates 710 MW capacity by 1985 and San Diego Gas Electric about 1,500 MW.

The technological difficulties experienced to date in the Salton Sea area, and the not completely successful results of drilling in the East Mesa and Dunes area, suggest that the SRI estimate may be of greater validity. Until further data on temperature distribution, porosity, permeability, and mineral content of the water become available, reliable estimates of the heat available will not be possible; and until the technological restrictions such as the low temperature limit of useful fluids and efficiencies of production methods are better known, estimates of the power production capabilities of any area will be largely speculative. Refer to Volume I, Chapter II for a complete explanation of geothermal resources potentials.

#### a. Salton Sea KGRA

Estimates of the ultimate capacity of the Salton Sea geothermal field are as high as 500 MW for 50 years (State of California, 1971). The known extent of this field is 18 km<sup>2</sup> containing a reservoir of about 35 km<sup>3</sup>. Porosity has been estimated to be as high as 20. Drilling in the area has shown that temperature as high as 680°F exist at depth.

The fluid contained in the reservoir is a hypersaline brine with higher concentrations of several valuable elements. This brine could provide a valuable source of potash, calcium chloride, lithia, and other minerals.

#### b. East Mesa, Glamis, and Dunes KGRA's

Few data are available on which to base an estimate of the resources in the East Mesa, Glamis, and Dunes KGRA's. Dutcher et.al.(1972) present, as figure 20 in their report, a map showing the thickness of deposits with water of greater than 150°C, less than 8,000 feet in depth, and less than 35,000 milligrams per liter dissolved solids. Using their map and

an assumed 10 percent recoverable water,  $12.2 \times 10^6$  acre feet of water are available at East Mesa,  $2 \times 10^6$  acre feet at Dunes, and  $25.5 \times 10^6$  acre feet at Glamis. It is not easy to convert these figures to electric capacity. Using the 3,000 MW capacity estimated by Stanford Research Institute (excluding the Salton Sea Geothermal area) one can estimate the capacity of the other KGRA's from data given by whose maps indicate that of the recoverable hot water in the Imperial Valley, 6.1 percent is in the East Mesa KGRA, 1 percent is in the Dunes and 12.8 percent in Glamis. If it is assumed that the electrical capacity is proportional to the percentage of hot water then the capacity of these KGRA's can be estimated as East Mesa 150 MW, Dunes 25 MW and Glamis 320 MW. Since these areas are the areas of greatest known temperature gradient they quite probably have more capacity for electrical production than this method of estimation. Approximately 25 percent of the capacity may be developed by 1985.

#### 4. Geothermal Resource Investigations

The possibility of geothermal development in the Salton Sea area was first explored in 1927 when three steam wells were drilled on Mullet Island. From 1932 to 1954 more than 65 shallow wells (less than 1,000 feet) were drilled along the southeastern border of Salton Sea west of Niland to supply carbon dioxide gas to a dry-ice plant, which operated from 1934 to 1954. In 1957 an exploratory oil-test well drilled about 4 miles south of the mouth of the Alamo River yielded large flows of hot brine, and since then 12 additional deep wells have been drilled in that vicinity in an attempt to develop the geothermal resources. Some of these wells have produced several hundred thousand pounds of hot brine per hour at well-head temperatures of 200°C. Reservoir temperature in the Salton Sea area is about 360°C.

The potential geothermal resources of the area between the Salton Sea field and the Mexican border have been the subject of a research program of the University of California at Riverside that has been carried out since 1968 with the support of the U.S. Bureau of Reclamation and others (University of California, Riverside, 1972). The Bureau of Reclamation, in coordination with the Office of Saline Water, has initiated a long-range program to study the technical and economic aspects of a joint electric power/desalination project to augment the water supply in the Lower Colorado River basin (U.S. Bureau of Reclamation, 1972). A preliminary appraisal of the ground water in storage with reference to the geothermal resources in the Imperial Valley was prepared by the U.S. Geological Survey in cooperation with the U.S. Bureau of Reclamation (Dutcher, L. C., et al. 1972).

Between 1968 and June 1970 the University of California investigators identified several areas with anomalously high temperature gradients of locally more than 10°F. per 100 feet of depth and carried out related geological and geophysical surveys. The most prominent of these thermal anomalies are found near Heber, just north of Calexico; at Brawley, about 20 miles north of Calexico; at Glamis, on the Southern Pacific Railroad; in the sand dunes east of the Coachella Canal; and on the East Mesa to the east of the Highline Canal. As a result of these findings, the Bureau of Reclamation in 1970 and 1971 performed further thermal gradient investigations, chiefly in the latter two areas, by drilling 18 boreholes to greater depths than the earlier work.

##### a. Salton Sea KGRA

Downhole pressure measurements in the Salton Sea geothermal area indicate a normal hydrostatic gradient, suggesting that the reservoir is a hot water system. The brines thus far encountered in this area contain large amounts of sodium, potassium, calcium, and chloride, as well as unusual contents of heavy metals. The total dissolved

solids in many wells exceed 200,000 parts per million - many times the salinity of sea water (about 35,000 ppm). Chemical analyses of two typical brines are shown in Table I-1. The hot saline waters are highly corrosive and technical problems of handling the waters have discouraged commercial exploitation of the geothermal energy. Production of saline and metallic by-products has not been perfected.

During 1972 and early 1973, eight wells were drilled for geothermal resources in the Salton Sea area. Their depths ranged from 2 to 4 thousand feet.

Table I-1. Calculated composition (in ppm by weight) of the reservoir fluid produced from the Shell No. 2 Imperial Irrigation District (IID) and Shell No. 1 State of California wells (from Helgeson, Amer. Journal of Science, v. 266, p. 129-166, 1968).

Constituent	No. 2 IID	No. 1 State
Sodium	53,000	47,800
Potassium	16,500	14,000
Lithium	210	180
Barium	250	190
Calcium	28,800	21,200
Strontium	440	
Magnesium	10	27
Boron	390	290
Silica	400	
Iron	2,000	1,200
Manganese	1,370	950
Lead	80	80
Zinc	500	500
Copper	3	2
Silver	1	1
Rubidium	70	65
Cesium	20	17
Chloride	155,000	127,000
CO <sub>2</sub>	500	5,000
S	30	30
Total Dissolved Solids	259,000	219,500

Magma and San Diego Gas and Electric constructing a pilot 10 MW binary-cycle power plant near Niland. This prototype closed-system plant is designed to transfer heat from hot water to isobutane which in turn will be used to drive a turbine. The binary system, if proven feasible, will have considerable attraction because there would be no discharge of geothermal fluids as they would all be returned to the geothermal reservoir. The cooling water requirement, which would be comparable to that of a conventional geothermal steam turbine

generator (roughly 50 acre-feet annually per MW of capacity), will be met by purchasing drainage waters from the Imperial Irrigation District.

b. Glamis KGRA

The only exploratory work conducted to date in the Glamis KGRA has been several shallow holes drilled by the University of California for temperature gradient data.

c. Dunes KGRA

The Dunes KGRA was identified by temperature gradient studies conducted in the Imperial Valley by University of California at Riverside from 1968 to 1970. As a result of these studies, six additional holes were drilled to depths of 375-562 feet. The maximum temperature reported was 231°F. A well on the Dunes anomaly was drilled by the California Division of Water Resources - to a depth of 2016 feet. The maximum temperature reported from this well was 218°F. at 850-890 feet. Total dissolved solids were 3,000 ppm at the bottom.

d. East Mesa KGRA

The majority of the geothermal exploration which has been carried out in the East Mesa area has been related to the Bureau of Reclamation's geothermal program. Between 1968 and 1970 University of California investigators performed reconnaissance temperature gradient measurements in the Imperial Valley. These measurements showed an anomaly in the East Mesa area. As a result, 9 temperature gradient holes were drilled to depths of 526 to 1420 feet. The maximum temperature recorded was 221°F. in the 1420-foot borehole (University of California, Riverside, 1972).

In the summer of 1972 a deep test well 8030 feet deep was drilled on the East Mesa anomaly. The Bureau of Reclamation planned to provide geothermal fluids to be investigated by the Office of Saline Water in a 96,000 gpd (maximum) desalting test facility (U.S. Bureau of Reclamation, 1972; Office of Saline Water, 1972).

Tests of this well indicate an estimated yield of 250 gpm from the well. Total dissolved solids in water from the well ranged from 1,850 ppm to 120,830 ppm. A sample from the producing zone was reported to contain 16,180 ppm total dissolved solids. The present salinity of the Salton Sea is about 36,000 ppm, or slightly more saline than seawater. In July 1973, the Bureau of Reclamation spudded a second geothermal test well in the East Mesa area.

## 5. Vegetation

### a. Salton Sea KGRA

Shoreline vegetation is sparse in some areas except for salt brush and salt grass. Rooted aquatic plants such as cattails, nutgrass, and other associated sedges are common at the confluence of freshwater drainages. Dense stands of salt cedar and cane are found near freshwater drainages. Salt grass is widely distributed wherever fresh water enters the sea and grows partially submerged in the water. On Federal and State refuges in the Salton Sea KGRA freshwater marshes containing alkali bullrush and cattail are found. On levees of the Alamo and New Rivers, above the influence of salt water, two species are found in abundance: arrowweed, which forms dense thickets, and a small herb, hiliotrope. Extensive agricultural developments are located in the area. Some upland areas are dominated by creosote bush and mesquite.

### b. Glamis KGRA

Within this area of approximately 50 square miles, 3 major and one minor vegetative community can be found. These communities are more distinct than most found throughout this desert region.

(1) Bajada Mixed Community: The bajada community is located along the eastern edge of the Glamis KGRA and east of the dunes. The bajada are the alluvial fans associated with the Chocolate Mountains to the east, and a continuous slope has been formed along the foot of the Glamis dunes. This community occupies approximately 30% of the Glamis KGRA.

The general aspect offered is a mixed lower sonoran shrub type that is well developed, with ironwood, creosote, octillo, mesquite, palo verde, smoke tree and desert willow making up the majority of the perennial shrub species. The area consists mainly of stable soils with a moderate to well developed desert pavement or surface rock. There is very little active soil or sand movement within this community.

Ephemeral species include desert gold, browneyed primrose, dune primrose, plantago, and numerous others that can be observed only when seasonal conditions are appropriate. The forb expression is at its peak during the moist and cool late winter season.

Ironwood reaches its ultimate development in this area. Very large and abundant trees can be found along the washes flowing west from the Chocolate Mountain and the east side of the railroad. But, as one moves to the west, this species is generally distributed throughout the community. From near the base of the dunes to the extreme west edge of the bajada, water accumulates during heavy storms, sometimes to a depth of 6 to 7 feet. Adjacent areas support a variety of ephemerals and considerably

more "lust" perennials than the general type. Of special significance is the occurrence of two annual mallows Sphaeralcea orcuttii and S. coulteri within the sinks. Both species are considered rare in California.

(2) Dunes Community: There is currently considerable scientific interest in the flora of the shifting dunes within this KGRA. There are several species which occur within the area that have not been found anywhere else in the United States. Wild sunflower, croton palafoxia, and desert buckwheat are the more obvious species which persist in the shifting sand areas. Near the eastern edge of the dunes, but still within the active sand area, sonoran desert trees can be found. The more significant of these include ironwood, desert willow, smoke tree and mesquite, existing in association with the sink areas which offer additional moisture. It has been noted that palo verde reaches its ultimate expression in California on these same sites near the sinks. The dunes community comprises approximately 55% of this KGRA. (Photo I-2)

(3) Creosote Forest Community: This type, covering approximately 15% of the KGRA, is located along the western edge and is associated with the Coachella Canal. Creosote bush within this area is of botanical significance. Here the species can be found not only in unusual abundance, estimated at 700 plants per acre, but also of a size seldom reached throughout its distribution, attaining heights of over ten feet. Within this area creosote also exhibits a physiological characteristic which is not at all typical of the species and may be unique within the species distribution, at least in California. Here, this desert shrub does not go into permanent wilt, a condition common to the species in which leaves are lost during times of extreme moisture stress. The absence of this characteristic is undoubtedly associated with the seepage from the Coachella Canal.

Associated with the Creosote bush in this area is ephedra, mesquite, happlopappas, and desert buckwheat, all of which exhibit unusually healthy and thriving characteristics. No other species of special significance has been noted within the community at this time. However, there is currently very little information available.

#### c. Dunes KGRA

This area contains two basic communities, neither of which are vegetatively significant as far as producing unusual or rare plants. However, they will be identified and briefly discussed. The Dunes KGRA covers approximately 12 square miles.

(1) Creosote Community: This creosote community is the poorest example of an association of this species found within the region. Shrub densities do not exceed 100 plants per acre and are small, dying back or wilting frequently. The area appears to be somewhat marginal for many of the desert species and appears to be a transition zone between the more developed desert shrub and the free-moving sand dunes. This community, which comprises approximately 50% of the Dunes KGRA, offers a limited diversity of species, particularly during warm seasons.

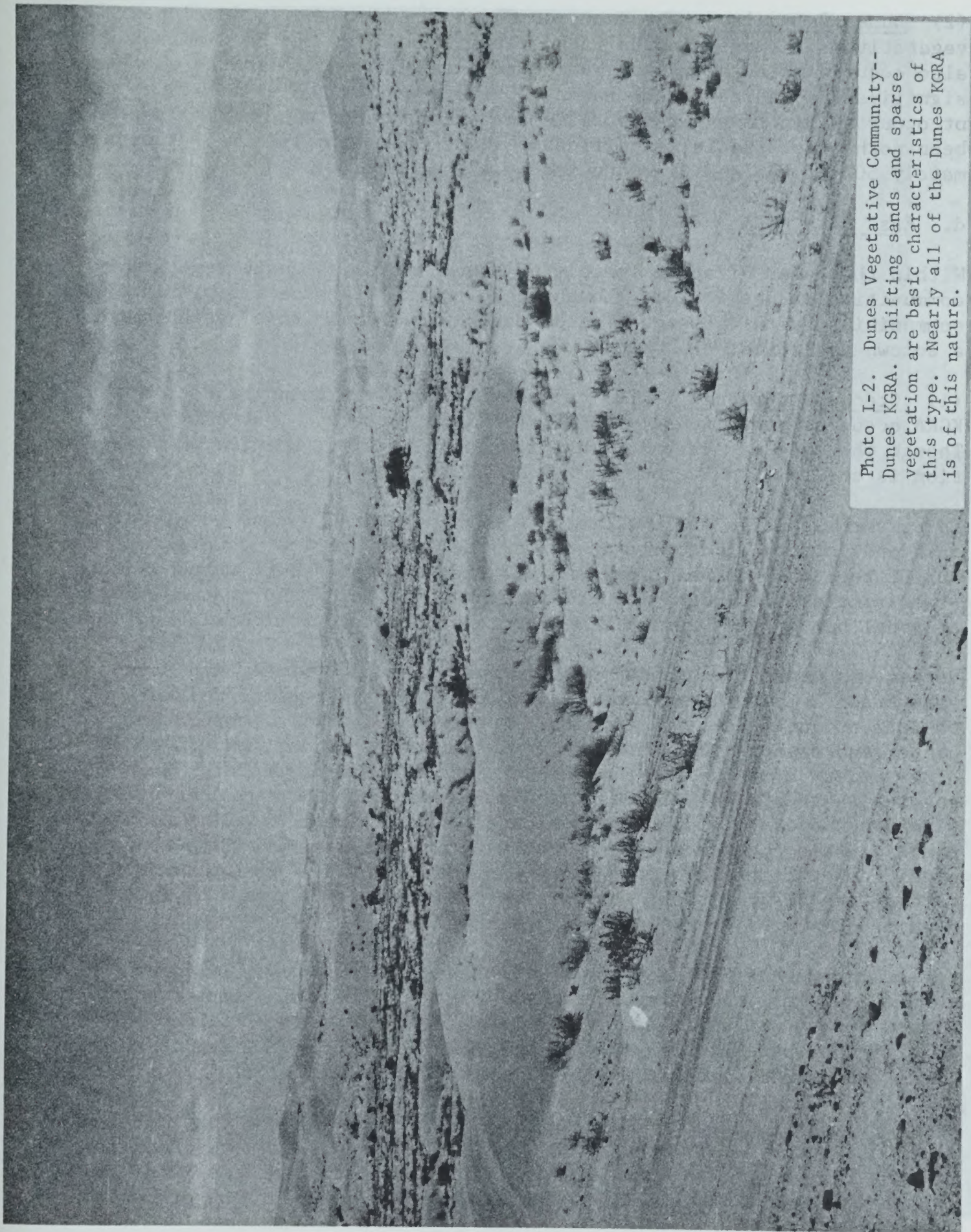


Photo I-2. Dunes Vegetative Community--  
Dunes KGRA. Shifting sands and sparse  
vegetation are basic characteristics of  
this type. Nearly all of the Dunes KGRA  
is of this nature.

(2) Dunes Community: The dunes community is also poorly developed vegetatively. Those species found within the dunes of the Glamis KGRA also occur within this area, but current information indicates that the significant botanical characteristics found within the Glamis dunes do not occur within this KGRA, but lie some distance to the east. There has been nothing of special significance identified at this time. Approximately 50% of the KGRA is occupied by this community.

d. East Mesa KGRA

Within this area of approximately 60 square miles, 3 basic vegetative communities can be found. Though there are similar species within these communities, with the exception of the agricultural lands, each one offers a somewhat distinct aspect.

(1) Creosote Community: The creosote community within the East Mesa KGRA occupies approximately 50% of the land surface. (Photo I-3) Though the type may vary somewhat from site to site, species composition is the same throughout.

Major shrub species include creosote bush, ephedra, cheese bush, brittle bush and coldera. Creosote is by far the major species, comprising over 90% of the total composition, and offering a large desert shrub aspect. Other species, including low growing ephemeral forbs and grasses are only seasonal but do play a significant role within the total biological complex.

Herbaceous vegetation falls into two basic groups - winter and summer ephemerals. These two groups respond not only to specific moisture conditions but also fairly finite temperatures. Cooler temperatures of winter and associated rainstorms results in the germination and growth of a variety of flowering plants both in color and character. Such species as spectacle-pod, desert gold, browneyed primrose, dune primrose, plantage and crytantha are common under these climatic conditions. Other forbs may also be found but generally occur less frequently. Of special significance is the desert lily, a species considered rare throughout much of its distribution; however, this species is more common in the Glamis dunes area to the north.

Summer ephemerals are restricted to a handful of species including sandmat, gramma, and a few mustards. Those plants, both summer and winter forbs, which are not utilized as food or nest material by the local fauna, persist for some time as dead herbage on the ground surface, and actually assist in holding sandy soils in place.

(2) Agricultural Lands: On the extreme west edge of the East Mesa KGRA there are about 5 square miles of agricultural lands. These lands make up less than 10% of the area and the mineral estate to these lands are privately owned. The government has no control over surface or subsurface resources.

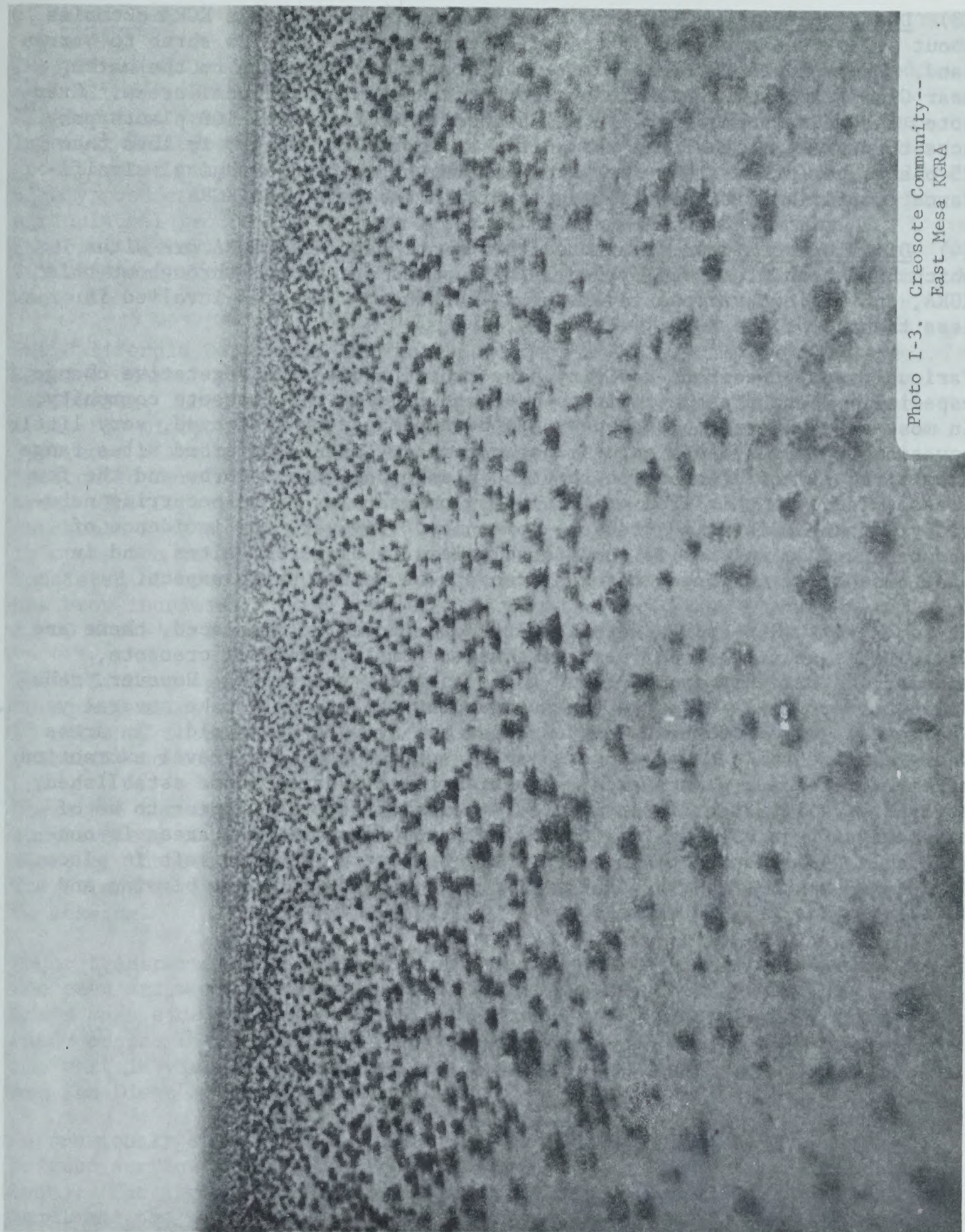


Photo I-3. Creosote Community--  
East Mesa KGRA

V-321

(3) Dunes Community: The sand dunes community within this KGRA occupies about 40% of the area and offers an aspect ranging from low shrub to barren land. These dunes are less active and dramatic than those to the north near Glamis and some vegetal development has occurred in local areas. Creosote, the major shrub species, has a density of less than 100 plants per acre throughout most of the community, and normally density is less than 25 plants per acre. There has been nothing of special botanical significance identified with this community within the East Mesa KGRA.

(4) Disturbance Sites: Scattered throughout East Mesa KGRA are sites which have been disturbed by man. These sites are common throughout this KGRA, and reflect various levels of disturbance. The area involved is less than 1% of the KGRA.

Various types of surface activity have caused noticeable vegetative change, especially where these activities have occurred in the creosote community. In most cases where the shrubbery has been damaged or destroyed, very little invasion of larger brush species has occurred. These disturbed sites range from virtually no creosote to about 50 plants per acre. Forbs and the few grasses found in this area are basically the same as those occurring naturally in the undisturbed creosote community. However, the incidence of shrubs or woody species is considerably less in disturbed sites, and in many cases they no longer offer a creosote or desert shrub aspect.

In some areas where surface soils were not removed or displaced, there are indications of some shrub reestablishment. Small plants of creosote, ephedra and caldonia can be found to be sparsely scattered. However, rehabilitation of these sites to the surrounding aspect would take several years. The mature stands of these woody species are over 50 years old. In areas where surface soils have been displaced, such as sand and gravel extraction sites, some exotic plants such as russian thistle have become established; however, the invasion of these sites by exotics does not appear to be of major significance. The incidence of young shrubs in these areas is considerably less than on those sites where surface soils were left in place. It can be expected that rehabilitation will be slow and that blowing and shifting sands will be common.

## 6. Land Use

The principal land use and industry in the Imperial Valley is irrigated agriculture. Water from the Colorado River, delivered through the All-American Canal System, currently supplies some 500,000 acres in the Imperial Valley and Coachella Valley. In Mexico, the Alamo Canal and ground water pumping supply water to 400,000 acres in the Mexicali Valley. Highly productive soils and a 365-day per year growing season account for agricultural production of more than 300 million dollars annually in Imperial Valley. This industry is entirely dependent upon the successful management of the irrigation systems and the disposal of irrigation wastes.

The California Department of Fish and Game and U. S. Fish and Wildlife Service operate wildlife management areas on the southern end of the Salton Sea. Both are oriented toward providing resting and feeding areas for migratory waterfowl which travel the Pacific Flyway. The 3900 acre Wister Unit of the State's Imperial Wildlife Management Area is located here. The only fresh water lakes in the Valley are on the area. The Department's first hatchery for the mass production of catchable-size channel catfish is located on the unit. It was placed in operation in 1970. Salton Sea National Wildlife Refuge originally consisted of over 32,000 acres; however, all of the original refuge has been inundated. Land management activities are confined to about 2,500 acres of leased land adjacent to the refuge boundary.

The U.S. Navy operates the Salton Sea Test Base, which includes about 80 square miles of land and water in the southern end. Approximately 10 miles of shoreline is located within the base. Activities relate primarily to testing of military equipment.

There are two marinas, Red Hill Marina located near Mullet Island at the southern end of the Salton Sea, and Niland Marina on the southeastern shore of the Sea, 11 miles north of Niland, are located in the KGRA. The Niland Marina is located near Federal lands that could be subject to leasing.

Major transportation routes include State highways paralleling both the east and west sides of the Sea, and a railroad line paralleling the Sea's east side. Interior circulatory roads of varying quality provide ready access to most of the study area. Access into the basin from the west is via interstate freeways connecting with the Los Angeles and San Diego metropolitan areas.

As previously stated, most of the land in the Imperial Valley area is private surface and mineral estate. (See map in pocket at end of statement). The irrigated land on the valley floor, between the East Highline Canal and the West Main Canal, is mostly privately owned. The bed of Salton Sea is largely natural resource lands; however, the lands in the Salton Sea National Wildlife Refuge are excepted from leasing, and much

of the rest of the Federal land is withdrawn from entry.

Land use in the East Mesa KGRA is primarily recreational, for example off-road vehicular use by motorcyclists. Mineral materials extraction is also common along the shoreline of ancient Lake Cahuilla, where sand and gravel deposits are mined.

Recreation is the primary land use in the Glamis and Dunes KGRA's; specifically off-road vehicle use by dune buggies. Use on winter holiday weekends is as high as 25,000 to 35,000 visitors, with most of the use concentrated in the Glamis KGRA. Other recreational uses in these KGRA's include sightseeing, photography, camping, rock collecting, and fishing and swimming in the Coachella Canal. Study and research activities are conducted in the KGRA's by local universities.

## 7. Fish and Wildlife

### a. Salton Sea KGRA

The Salton Sea contains a variety of aquatic life limited partly by the drastic chemical and physical changes that occurred during the period from its formation in 1907 to its near stabilization in the early 60's. Water temperature is high in the summer (up to 97° F). The Salton Sea has low dissolved oxygen retention during the summer, and a salt composition similar in concentration, but different in ionic composition from ocean water. (U.S. Department of the Interior, Federal Water Quality Administration, Pacific Southwest Region, July 1970).

The original populations of fish were introduced into the Salton Sea by the flooding Colorado River during 1905 through 1907. The fish species introduced by the flooding river were carp, bonytail, humpback suckers, various centrachids and rainbow trout. Striped mullet and ten pounders migrating upstream from the Gulf of California also were carried in. As the salinity of the Sea increased, due to the high evaporation rate and the dissolving of soluble salines in the lake bottom, the fresh water species could not survive, leaving only the striped mullet in this highly saline lake. The desert pupfish, native to the area, adapted to more brackish water, has survived.

From 1929 through 1950, numerous fish species were transplanted to the Sea in order to establish a sportfishery. Most of these species did not survive. The mudsucker, transplanted from San Diego Bay did become established. From 1950 through 1956, numerous fish species were introduced from San Felipe on the Gulf. Only three species survived to form the present fishery. These are the orangemouth corvina, sargo, and bairdiella (gulf croaker). Additional species including the threadfin shad, sailfin molly, and mosquito fish, have inadvertently become established.

Since the initial stocking in 1929, the Salton Sea has grown to be the largest and most productive inland fishery in California. Unlike most other inland waters, natural reproduction sustains the fishery.

Invertebrate animals such as the clam, mussel, shrimp, oyster, crab, squid, mysid, and polychaete worm (pile worm) were introduced to provide food for fish and man. Some species were introduced unintentionally during fish transplants or by boats and seaplanes used in the Sea from other bodies of water. Like the fish, most of these animals were unable to survive. Today, there are only three known kinds of macroinvertebrates in the Sea; they include the pile worm, barnacle, and amphipod. Microscopic forms including protozoa, bryozoan, nematodes, a rotifer, ostracods, and copepods have been reported.

Adult pile worms are found in the mud bottom. They die soon after spawning at the surface, and the immature forms are present in the water

column for sometime until they mature and go to the bottom. Barnacles are extremely abundant and attach in almost solid colonies to rock, sticks, piles, boats, and other hard substrate. The amphipod is found on rocks along the shoreline and in open water. The small (microscopic) invertebrates such as protozoans and small crustaceans like copepods graze on algae and provide additional support to the food cycle of the Sea.

Plant life is predominantly single-celled algae floating in the water. The individually-floating plant cells (phytoplankton) are microscopic and visible only when their numbers are great enough to color the water. The only plants large (macroscopic) enough to see are blue-green algae whose massed growth is visible near the shore.

The introduction of fish and invertebrates has led to the formation of very simple food chains. The chain is formed by the following links: phytoplankton, zooplankton, detritus, benthic invertebrates, invertebrate-eating fish, and fish-eating fish. In general, each link is composed of one or two dominant species which occupy a trophic level, with each level dependent upon the success of the next lower level in the system. The detritus-feeding pile worm (neanthes) is the prime trophic resource of sargo and bairdiella, the forage fishes, which in turn serve as food for orangemouth corvina, the top carnivore in this system.

Most prominent is the plankton-detritus-neanthes-bairdiella-sargo-corvina chain. The plankton organisms, upon death, sink to the bottom and form a layer of organic debris (detritus) which is rich in food materials. This detritus is eventually broken down into its simple components by bacteria and other organisms; however, this process is relatively slow and the detritus therefore represents a temporary reservoir of basic food materials. The detritus is eaten by the worm, neanthes, which in turn is eaten mainly by bairdiella and sargo, to a lesser extent by corvina. (U.S. Department of the Interior, Federal Water Quality Administration, Pacific Southeast Region, July 1970).

A more efficient, but minor, food chain is the plankton-plankton-eating fish (threadfin shad) - predator fish (corvina). Corvina also feed on desert pupfish near freshwater inlets and on the numerous mollies which inhabit the shore zones during warmwater months.

Striped bass, black crappie, channel catfish, bluegills, largemouth bass and various non-game fish exist in the main canal system. The endangered Colorado squaw fish may also frequent the canal system.

The valuable fishery and marine life in the Salton Sea attest to the high productivity of the existing system. However, ecological theory suggests that such a simplified system gains its high productivity at the risk of some inherent instability - because loss of a single link in the food chain could cause the entire system to collapse.

The Sea may be unable to support fish life for more than another ten years,

because of increasing salinity. It can be predicted with some assurance what would happen to the fishery in the Salton Sea if salinity is not controlled. At or near 40,000 part per million (ppm) reproduction of the game fishes would probably decline as a result of egg and larval mortality. Should the salinity fluctuate around the 40,000 ppm level for a period of years, the fish may spawn successfully in some years but not in others, providing a rather unstable fishery. Older fish may continue to live long after spawning ceases. However, they would grow more slowly and become thinner and less desirable for sport fishing as the salinity rises. (U.S. Department of the Interior and the Resources Agency of California, October 1969).

In addition to salt, the Sea water is rich in dissolved compounds of nitrogen and phosphorous. These nutrients are responsible for a large production of algae which frequently discolors the water over large areas. Although algae are an essential part of the food chain supporting the fishery, the overabundance produces undesirable eutrophic symptoms. Death and decay of large algae populations result in temporary oxygen deficiencies that occasionally cause localized fish kills. Floating mats of unsightly scum are frequently seen near the shoreline. Unpleasant odors usually accompany these conditions.

However, water quality surveys indicate that only a small part of the total nutrient inflow is retained in the Sea water, apparently because of nutrient assimilation by the ecological system and deposition in the bottom sediments. This nutrient trapping capability has maintained the Sea at about the same rate of eutrophication since 1955 and would probably continue to do so in the future.

The Alamo and New River deltas contain valuable wildlife habitat. They represent a large portion of the "natural" habitat which exists in the Imperial Valley today. The coyote, desert fox, racoon, bobcat, skunk, badger, as well as muskrat, cottontail, and jackrabbit, are present. A variety of rodents, such as the roundtail ground squirrel, valley pocket gopher, desert pocket mouse, and desert kangaroo rat, exists in the area.

The following endangered species are known to occur in the Salton Sea KGRA: brown pelican, southern bald eagle, American peregrine, Yuma clapper rail and California least tern. These species are listed by the Secretary of the Interior and the California Fish and Game Commission as endangered. The brown pelican and American peregrine falcon also are listed by the Secretary of the Interior on the U.S. List of Endangered Foreign Fish and Wildlife. The brown pelican, southern bald eagle, and American peregrine falcon utilize the area for feeding and resting. The Yuma clapper rail, the smallest of the clapper rails in California, inhabits marshes along the Salton Sea. It nests in dense vegetation around the Sea. The California least tern has been reported as casual or accidental.

The Sea is of extremely significant value to waterfowl and other water-associated birds. Part of the area has been designated as the Salton Sea Wildlife Refuge. The most attractive areas for waterfowl are at both ends of the Sea where marshes, cover, and mudflats are located. The areas around the mouths of the three main rivers - the Whitewater, New, and Alamo Rivers - are by far the most productive for all waterbirds. (California Department of Fish and Game, 1970). On the east and west shores, water associated birds are found where suitable habitat is present. Agricultural developments at the south end attract large numbers of birds.

Salton Sea is the winter home of the Canada, snow, and whitefronted geese. Ross's, cackling, and blue geese also can be found in lesser numbers at certain times. Numerous species of ducks such as the pintail, American widgeon, and green-winged teal use the Sea.

No other comparable area in the West has the tremendous flocks of shorebirds which each year use the Sea and surrounding area. Thirty-five species of shorebirds and 47 species of waterbirds, exclusive of swans, ducks, geese, cranes, and rails have been recorded. (California Department of Fish and Game, 1970). The American avocet, black-necked stilt, willet, sandpiper, marbled godwit, plover, yellow-leg, and phalarope - some in large seasonal flocks - use the Sea for a place to feed and rest.

In the summer, gull-billed terns and laughing gulls, which have nested nowhere else in the western United States, are present. Black skimmers have just recently started nesting at the tip of the New River Delta. An egret rookery is also present.

Upland game birds inhabiting lands adjacent to the Sea include mourning, white-winged, Mexican ground doves, Gambel's quail, California quail, and ring-necked pheasant. The highest population of doves in the West is found here.

This is the native haunt of the roadrunner, cactus wren, verdin, and many other strictly desert species. Blackbirds, swifts, woodpeckers, falcons, owls, hawks, and an infinite variety of song and perching birds visit. These and other nongame animals contribute to the public enjoyment of natural living resources. Many species of amphibians and reptiles are found in the area. Amphibians include the southwestern woodhouse toad, red-spotted toad, and bullfrog. Many species of lizards, such as the zebra-tailed lizard, western whiptail lizard, and fringe-toed lizards. Rattlesnakes are present along with nonpoisonous species such as the western blind snake, desert glassy snake, and western long-nosed snake.

Salton Sea National Wildlife Refuge is primarily a wintering area for an important segment of the population of migratory waterfowl which travel the Pacific Flyway. (Photo I-4) It was established in 1930 for the protection of ducks, geese, and shorebirds. In addition to protecting wildlife, the refuge has the parallel purpose of controlling depredations on adjacent croplands.

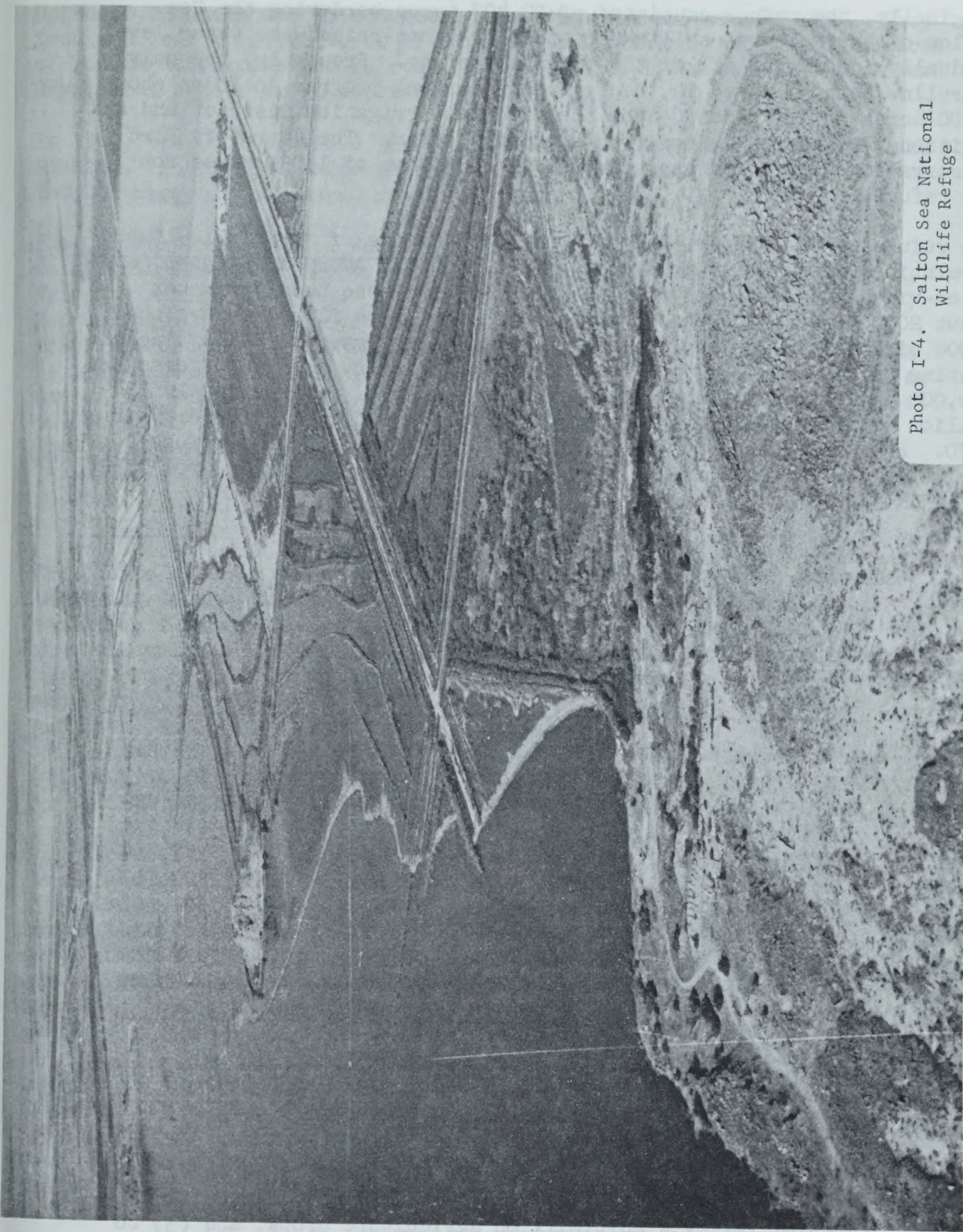


Photo I-4. Salton Sea National  
Wildlife Refuge

Originally, the refuge consisted of 32,407 acres bordering the Sea. Inflow of agricultural spillwater since 1930 has raised the water level gradually inundating all of the original refuge. Presently, the only shoreline being managed in the Federal waterfowl program includes about 2,400 acres of land leased from the Imperial Irrigation District and an additional 160 acres leased from a private owner. The Migratory Bird Conservation Commission has approved the addition of 1,034 acres for the refuge.

The refuge is the winter home of tens of thousands of waterfowl. Duck populations, consisting primarily of the pintail, American widgeon, and green-winged teal, exceed 200,000 birds. Snow geese usually number about 20,000 birds and the great basin Canada goose flock reaches the 8,000 bird level. Canada geese wintering in the Imperial Valley include nesting birds from the intermountain west. As many as 55,000 geese and 200,000 ducks have utilized the refuge at one time. Approximately 15 million waterfowl-use days occurred on the refuge during calendar year 1970. For statistical purposes, one duck or goose using the refuge 1 day is called a waterfowl-use day. The table below shows use from 1962 to 1971.

**WATERFOWL USE-DAYS 1962 - 1971**  
**SALTON SEA NATIONAL WILDLIFE REFUGE**

Year	Ducks	Geese	Coots	Total
1962	3,462,461	655,457	715,925	4,833,843
1963	8,592,850	1,109,108	799,785	10,501,743
1964	16,911,334	2,070,640	2,604,980	21,586,989
1965	10,122,685	1,830,248	483,005	12,435,938
1966	8,433,369	1,258,131	703,640	10,395,140
1967	8,100,288	1,307,524	479,355	9,887,167
1968	5,179,896	543,991	577,675	6,301,562
1969	5,914,185	1,080,576	530,775	7,525,536
1970	13,094,403	1,050,987	891,975	15,037,365
1971	8,074,647	924,469	767,650	9,700,000

The California Department of Fish and Game's Imperial Wildlife Management Area consists of 8,400 acres and is "farmed" for wildlife food production. The 3,900 acre Wister Unit of the Imperial Wildlife Area is adjacent to the southeast corner of the Salton Sea in Imperial Valley. Wister serves three basic purposes: (1) to help preserve California's waterfowl resource and associated wildlife, (2) to attract and hold wintering waterfowl off Imperial Valley's multimillion agriculture crops, and (3) to provide public hunting, fishing, nature study, and related uses.

Up to 50,00 ducks and 35,000 geese make Wister their winter home. They feed and loaf on 2,700 acres of manmade ponds, an additional 1,000 acres of ponded watergraws and bulrush, and more than 1,000 acres of green and dry cereal grains grown expressly for the birds.

In 1969, the Unit provided 32,800 recreational days, mostly hunting and fishing. Future use under present development plans would provide over 140,000 recreational days, mostly fishing.

The California Protected Waterways Plan published by the State of California Resources Agency designates the Salton Sea as a Priority A, Priority Action Waterway. (State of California, The Resources Agency, February 1970). Waterways under this priority have the highest priority and detailed protected waterway management plans for them should be undertaken immediately. The plan also lists the Salton Sea Marsh as one of the Scenic waterways of California's landscape provinces (Desert and Desert). It also lists Salton Sea marshes under Class II - Very Good Waterways (these areas exclude Federal refuges and state-owned "wildlife" areas).

b. Glamis KGRA

The Glamis area offers more in variety of habitats than any other KGRA involving desert communities within the Imperial Valley complex. Mammalian inhabitants are basically the same as those found within the East Mesa KGRA. However, their frequency or relative abundance appears to be greater within the Glamis area. Twenty-three species of mammals, 39 species of birds, 26 species of reptiles, 2 species of amphibians, and 59 different species of insects have been identified in this area thus far. (Studies by University of California). Further investigation and study probably would increase this species list, especially that of the invertebrates.

The presence of the rare spade footed toad which is associated with the transient pools or sinks resulting from summer storms is of special significance. These storms may occur only once every 3 to 5 years; but when they do come the small toad is able to emerge from its capsule beneath the sand and carry on its life cycle. This species may only appear on the surface for a few weeks during exceptional moisture conditions, and then return to its underground retreat, possibly for as long as four years.

Relatively rare species of reptiles which can be found within this area include the western diamondback rattlesnake, desert horned lizard, the desert tortoise, western collared lizard, desert iguana, western chuckwalla, zebra-tailed lizard, flat-tailed horned lizard, and the long-nosed leopard lizard. (Photo I-5) Virtually nothing is known of the status of these species within the Glamis KGRA.



Photo I-5. Bajada Community--Glamis KGRA.  
Desert Iguana found throughout most vegeta-  
tive communities within the KGRA. This large  
lizard appeared to be locally abundant.

Of the 39 species of birds which have been identified within the area, only a few are residents. The roadrunner and LeConte's Thrasher are among those that have chosen this area as home. Little is known of the birdlife within this area and additional information is essential before the total biological complex can be interpreted.

Some 59 species of invertebrates have been collected from the Algodones Dunes in which the Glamis KGRA is located: (Studies by University of California). Of those that have been identified, 44 species are expected to be endemic to the area and two species are yet un-named. It is very possible that yet unseen and unidentified species may be found within the Algodones (Glamis) Dunes. The nocturnal habits of this group of animal life has made inventories difficult to obtain.

There are a few areas within this KGRA which offer additional wildlife values. These include the creosote forest type associated with the Coachella Canal, located on both the east and west bank of the waterway, and the small seep areas also along the canal. The sink areas on the eastern edge of the sand dunes which support higher densities and a greater variety of vegetation are also significant. These habitat areas, due to their more complex and productive vegetation, have been referred to as desert wildlife farms. The density and variety of animal life associated with these sites are considerably greater than in the general communities in the area. The availability of water, either on a permanent or intermittent basis attracts animals from surrounding areas. Many mammals and birds utilize these areas as a food and succulent source, and nearly any time during the year one can observe a variety of animal life or the signs left by their presence. Those seeps which offer permanent standing water also support unique aquatic communities. Little is known about these seeps, but complete aquatic food chains do exist including largemouth bass at the top of the food chain. These small ponds support basically closed ecosystems with all components functioning free of man's constant interference. Unfortunately, the existence of these sites ultimately ties back to man's demands and use of the area, in that the water feeding these ponds very likely is associated with seepage from the Coachella Canal. Any major changes in this waterway, such as sealing could effect the productivity and character of these systems.

#### c. Dunes KGRA

The Dunes KGRA offers the least variety and consistently the most harsh environment of all the KGRA's under study. Vegetation is poorly developed and of limited variety. Water is extremely scarce except on the extreme western edge of the area which the Coachella Canal traverses. It is expected that many of the species listed in the appendix utilize the area, but there is very little information available which applies specifically to the Dunes KGRA. Nothing of special significance relating to wildlife of the area has been identified at this time.

d. East Mesa KGRA

Due to fairly uniform characteristics of the associated habitats within the East Mesa KGRA, a wide variety of wildlife species does not occur here. However, there is an abundance of those species which have taken up residence and also of those migrant species which utilize the area during winter months. Among the residents, ground squirrels, mice, kangaroo rats, occasional kit fox, coyote, badger, and bobcat comprise the majority of mammals species. None of these, however, are of particular significance although all are important in maintaining the existing biological complex.

Reptiles are well represented, with over 20 species recorded as inhabiting the area. The more significant species include the western diamond back rattlesnake (rarely seen), flat-tailed horned lizard, desert horned lizard, zebra-tailed lizard, western collared lizard, long-nosed leopard lizard, western chuckwalla, and the desert iguana. These species are considered as being threatened throughout much of their natural distribution. Current information indicates, however, that populations of certain of these species appears to be considerably higher than previous years. The desert iguana and the western chuckwalla are two species which appear to be on the increase within this area.

Over 30 species of birds have been identified in the area. Many of these are winter migrants using the area for just a few months during the winter season. Resident birds include the roadrunner and LeConte's Thrasher and can be found over much of the area. No other significant species have been identified at this time.

Invertebrates are also well represented with this KGRA. Over 50 species have been identified, and many are believed to be endemic. Of special interest is the possibility that 10 varieties of scorpions are residents of East Mesa, (2 have been identified thus far) and nearly 30 species of beetles may be found. Most insects inhabiting the area are nocturnal and cannot be observed during daylight hours. However, during early hours of the morning and before sands begin to move, signs of the previous night's activity can be interpreted from the surface. Over half of the invertebrates found within the area are expected to be endemic to eastern Imperial County, California.

## 8. Water Resources

Water in the Imperial Valley occurs in a desert environment modified by extensive agricultural development that depends on imported surface water. Sources of water in the area include: Precipitation (less than 3 inches per year on average), ground water, and imported surface water from the Colorado River. The Salton Sea forms a sump for water in the area tributary to the sea, including the Coachella Valley to the north. Water leaves the sea only by evaporation.

### a. Ground Water

In the Imperial Valley and vicinity, ground water occurs in a multi-aquifer system with a water-table aquifer over-lying pressurized aquifers. Hydrologic characteristics of the system have been described by Dutcher and others (1972, p. 15) and California Department of Water Resources (1970, p. 30-32).

#### (1) Hydrologic Characteristics

The hydrologic characteristics of the sediments to a depth of about 1,000 feet are known generally from pumping tests of numerous shallow water wells. Water yield and formation permeability of the deeper rocks and deposits are difficult to estimate because few quantitative data were available for examination.

A larger area in the central part of the valley contains flowing domestic wells; these extend from 6 miles south of Holtville to several miles north of Calipatria. The Alamo River flows along the western limit of the area of flowing wells. Shallow wells drilled by the Geological Survey show that the area of artesian pressure extends farther west, but west of the Alamo River the pressure is insufficient to cause wells to flow. An inventory of more than 100 flowing wells, ranging in depth from 350 to 1,300 feet, shows that the discharge ranges from 10 to 100 gallons per minute. Data indicates unfavorable conditions for development of large quantities of usable ground water within the area of flowing wells, and almost the entire central part of Imperial Valley. Aquifer tests at wells about 500 feet deep at Imperial and east of Calexico showed low transmissivity, about 2,000 gpd per ft (gallons per day per foot). Thus, specific capacity of wells may be about 1 gallon per minute per foot of drawdown. (The specific capacity of a well is the yield, in gallons per minute, divided by the drawdown, in feet, from the nonpumping water level in the well.) Ordinarily, wells having specific capacities less than about 10 are considered a marginal value for irrigation use.

A test well drilled to a depth of 560 feet by the Geological Survey on the West Mesa, 8 miles north of Plaster City has a transmissivity of the aquifer of about 150,000 gpd per ft.

In the East Mesa area, about 8 miles southeast of Holtville, the Bureau of Reclamation (1973) drilled a well (well 92, U.S. Bur. Reclamation 127) to a depth of 1,406 feet on a high heat-flow anomaly. (Photo I-6) Determination of permeability in millidarcies from a sidewall neutron log and a formation density compensated log, in the depth interval 204-1,400 feet, indicated an average permeability of 13 gpd per sq. ft.

Multiplying the average permeability value by the well depth gives an aquifer transmissivity of about 18,000 gpd per ft. By comparison, a well drilled 1,000 feet deep at the junction of the All American and Coachella Canals had an aquifer transmissivity about 10 times greater.

## (2) Conceptual System

Water level contours of the shallow aquifer system (Dutcher and others, 1972, p. 34) indicate ground-water movement toward the sea. The direction of ground-water movement in the deep aquifer system, as inferred by Dutcher and others (1972, p. 20), generally is toward the centers of known geothermal anomalies. Thus the flow in the deep aquifer system probably is notably different from that in the overlying, cooler water of the shallow aquifer system.

In their conceptual model of the hydrologic system, Dutcher and others (1972, p. 18 and 23) postulate a zone extending to a depth of nearly 3,000 feet below land surface wherein the aquifer system responds to recharge and discharge in a manner similar to that of non-geothermally influenced systems. Below a depth of about 3,000 feet, they have postulated convective circulation of brines recharged from the shallower system and expressed at the surface, where channels to the surface exist, by bubbling mudpots and gas bubbles in wells.

### b. Surface Water

The surface water resources of the Imperial Valley are almost entirely those provided by water imported from the Colorado River. Most of the surface water inflow to the Salton Sea is from Imperial Valley via the Alamo and New Rivers, which carry the tailgate wastewater from irrigation as their total flow. Flows in a number of small channels also tributary to the sea are insignificant compared to the two major sources. Hely and others (1966, p. C9) summarized the annual surface inflow to Salton Sea for the period 1944-62.

### c. Quality of Water

The chemical characteristics of surface water in the Imperial Valley area have been described by Hely and others (1966, p. C24), who showed that concentrations of dissolved solids in the Colorado River water, the lowest in the area, were modified by evaporation and transpiration in the irrigated areas and by solution from soils. The water that eventually

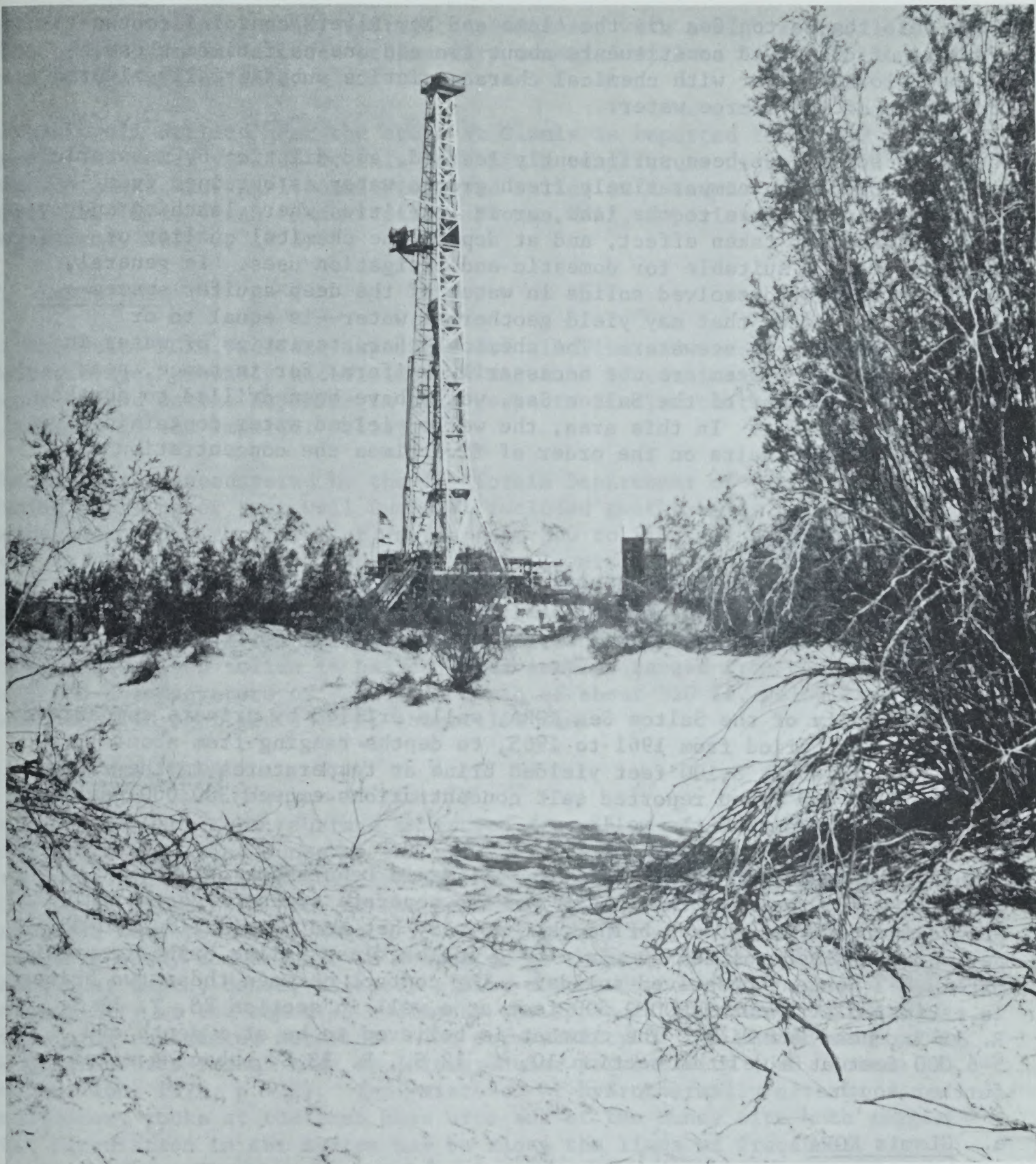


Photo I-6. Bureau of Reclamation Drilling on East Mesa

flows into the Salton Sea via the Alamo and New Rivers contains concentrations of dissolved constituents about two and one-half times those in the Colorado River with chemical characteristics substantially altered from those of the source water.

Where the soils have been sufficiently leached, and dilution by meteoric water has occurred, comparatively fresh ground water is obtained from wells. However, close to the lake, or in localities where leaching and dilution have not taken effect, and at depth, the chemical quality of the water is not suitable for domestic and irrigation uses. In general, concentrations of dissolved solids in water of the deep aquifer system--that is, the system that may yield geothermal water--is equal to or greater than that in seawater. The chemical characteristics of water in the deep aquifer system are not necessarily uniform; for instance, near the southeast corner of the Salton Sea, wells have been drilled to depths of about 5,000 feet. In this area, the wells yielded water containing concentrations of salts on the order of five times the concentration of seawater.

d. Salton Sea KGRA

At the surface, the Salton Sea KGRA is composed of the sea itself and lake deposits of Holocene age, probably overlying a section similar to that described by the California Department of Water Resources (1970, p. 14-15).

In the vicinity of the Salton Sea KGRA, wells drilled by private companies, mostly in the period from 1961 to 1965, to depths ranging from about 1,700 feet to about 8,100 feet yielded brine at temperatures in the range from 300° to 680°F and reported salt concentrations exceed 300,000 parts per million in some of the wells.

It has been suggested (Rex, 1968, in California Department of Water Resources, 1970, p. 44) that there are two separate types of geothermal brines in the area, a deep brine that is very hot and hypersaline (20-30 percent dissolved solids) overlain by a cooler, less saline brine (approximately 1-3 percent dissolved solids). The contact between these two brines is estimated at about 2,000-2,500 feet at a well in section 23, T. 11 S., R. 13 E., near Red Hill. The contact is believed to be at a depth of 5-6,000 feet at a well in section 10, T. 12 S., R. 13 E., about 4 miles further south.

e. Glamis KGRA

The Glamis area lies astride of the sand hills along the eastern flank of the Imperial Valley. The western edge extends onto non-marine sedimentary deposits of Pleistocene age. Geothermal test well drilling has not been undertaken in the Glamis area at the present time and consequently conditions in the subsurface cannot be described. Anticipated conditions are similar to those encountered at East Mesa and Dunes KGRAs with the entire

section underlain by sandy deltaic deposits and with a high probability that hydrothermally altered sedimentary material will be found at intervals below land surface.

A water well drilled near the store at Glamis is reported to be 700 feet deep. The water yielded by this well has a temperature of about 160°F and contained 3160 mg/l total dissolved solids in a sample collected April 16, 1973, (oral communication, Thomas Wolf, Imperial County Health Department, July 3, 1973).

f. Dunes KGRA

At the Dunes KGRA, surface exposures are alluvium and sand dunes of Holocene age, probably underlain by a sequence of continental deltaic deposits and marine deposits in some respects similar to those found elsewhere in the Imperial Valley.

The materials encountered by the California Department of Water Resources during drilling of test well Dunes #1 included geothermally altered sediments cemented with silica at depths from 360 to 510 feet and 790 to 900 feet below land surface: These siliceous layers indicate that there has been, in the past, subsurface discharge of hot fluids with high silica content, (University of California, Riverside, 1973, p. 10, 22-29 and 42-47). Yield from the well was not sufficient for testing. Concentration of dissolved solids in bailed water samples ranged from about 3042 mg/l and a temperature of 92°C at a depth of about 350 ft. below land surface, to 1260 mg/l and 83°C at about 1750 feet.

g. East Mesa KGRA

In the East Mesa KGRA, surface exposures are alluvium of Holocene age with occasional sand dunes on the surface. Surficial deposits probably are underlain by continental and deltaic deposits and marine deposits like those found elsewhere in the Imperial Valley. The materials encountered when test well Mesa 6-1 was drilled by the Bureau of Reclamation were sandy and deltaic in character to a depth of about 7,000 feet. Below that depth, dense, altered, silica-cemented rocks were found. The permeability of the cemented sediments was appreciably lower than that of over-lying uncemented material. The permeability of the tested section may be in fractures rather than to intergranular permeability (U.S. Bureau of Reclamation, 1973, p. 22). The existence of hydrothermally altered sedimentary rocks at the East Mesa site and at the Dunes site both suggests that circulation in the system may be along the lines of fractures.

Yield from the well, Mesa 6-1, in the section from 7200-8000 feet below land surface was about 250 gallons per minute of brine containing about 30,000 mg/l (milligrams per liter) dissolved solids (U.S. Bureau of Reclamation, 1973, p. 28).

## 9. Aesthetics

In the context of this discussion, aesthetics is defined as human perception and appreciation of the entirety of the components of an ecosystem. While "appreciation" is intangible and philosophical in nature, "perception" is a definitive phenomenon subject to a more direct analysis.

Various geographical locations have obvious differences in the scenic appeal of landscapes. In general, the factors affecting visual quality or "scenic appeal," making one landscape more prized than others, are: color, shape or pattern, scale or size, movement, texture or composition, diversity, and uniqueness.

### a. Salton Sea KGRA

The major feature affecting aesthetics in the Imperial Valley is the Salton Sea, a large body of water (230,000 acres in 1967) located within the driest climate in the U.S. It is easily accessible to one of the largest metropolitan areas in the U.S. so it is a major aesthetic attraction to land as well as air travellers. The Sea is a startling and pleasant contrast to the surrounding landscape.

The two rivers which flow into the Sea add materially to the aesthetic landscape because of their meandering characteristics and comparatively luxuriant vegetation along their banks. The marshes along parts of the lake shore and along the rivers, with their wide variety of vegetation and prolific shorebird and waterfowl populations, contribute significantly to overall aesthetics.

The overall biologic and water quality (i.e. water color, turbidity, water condition, algae content, and pollution) conditions of the Salton Sea are somewhat less than desirable.

Closely related to any discussion of aesthetics in this area is the fact that poor air quality due to fog and haze often detracts from otherwise pleasant aesthetic qualities.

### b. Glamis KGRA

Aesthetically, the Glamis KGRA encompasses a region of unusual scenic appeal. The character of the hot desert is different than that of the cold desert. Remnants of eroded mesas rise above broad flat areas. Where live streams run through the desert, erosion is active. Canyons are incised into once flat mesas. Sand dunes are present over large areas.

There are distinct horizontal and vertical lines evident in the sharp drop-offs to the valley floors. Color is a dominant factor in the hot desert. Rich reds and browns of exposed soil and rocks are in evidence and periodic wildflower and cactus blooms over wide areas

bring crowds of sightseers. Texture is fairly coarse because of the widely scattered vegetation. Rocks and soil are exposed over wide areas.

The major aesthetic characteristics of the dunes is the land form itself, though vegetation has some scenic quality in proximity to the Coachella Canal and especially on the northeastern edge of the proposed natural area. Wildlife also has aesthetic value. The hills of windblown sand consists of long, northwest trending ridges on the west which individually curve eastward and disappear in a complex of prominent southfacing slip faces. In the central and southern part some slip faces are 200-300 feet high and overlook large, flat-floored, sand free depressions (the desert floor) over which a succession of large, closely spaced barchans are advancing. Present conditions favor destruction of the depressions by encroachment of sand in the form of small linear ridges and barchan dunes from the transverse dunes. The major sand dune mass is moving about one foot a year in a southeast direction. Though primarily composed of barchans, transverse and longitudinal dunes, blowouts and depressions, the dunes area also has flat lands, washes, valleys and playas. The beauty and grandeur of the sand dunes formations are the primary aesthetic attraction, with added enrichment and accent afforded by the vegetative cover in some areas.

The air is generally clear and dry.

c. East Mesa KGRA

Visually, the mesa is monotonous, characterized by sparse vegetation and flat topography. Color, texture and patterns are generally minimal in terms of scenic appeal. It is bisected by Interstate Highway 80.

## 10. Archeological and Historic Resources

### a. General

Very little has been written on the archeology of Imperial Valley. Although many archeological sites have been located, only a small amount of thorough field work has been done. The chief reason for lack of knowledge of the cultural resources of the Valley stems from the prevailing climatic conditions. Malcolm Rogers conducted archeological reconnaissance surveys in the Colorado Desert during the late 1920's and early 1930's. Treganza (1942) conducted an archeological survey of southeastern Imperial Valley and northeastern Baja California. Treganza, using minimal scientific data, asserted that nearly all archeological sites north of the border were destroyed. Peck (1961), and Davis and True (1965) carried out further research in the Imperial Valley with little intensive field work. In 1970 Professors Barker and Burton of Imperial Valley Junior College began an intensive program utilizing sites heretofore unrecorded in the literature. Their investigations have been confined to the West Mesa.

Rogers (1938) and Warren and True (1961) assert that San Dieguito cultural traits are confined to chipped lithics: scrapers (keeled, flakes) large bi-pointed blades, choppers, etc. Grinding stones are notably absent. Wallace (1954) and Roger (1958) proposed the working hypothesis that San Dieguito was a derivation from Cochise culture of southern Arizona. Warren and True (1961) also suggest that San Dieguito may represent evidence of an early "Western hunting culture" dissimilar from and older than the Desert culture and that of Lake Mohave-playa cultures of the interior basin are manifestations of this hunting culture. The San Dieguito is obviously not well known due to the lack of reliable absolute dating to date.

The Yuman cultural horizon (Diegueno) represents the youngest incursion into the Valley of a people possessing heavy usage of ceramics, cremation type burials, and small projectile points.

Barker, Burton, and Childers' unpublished results of two early man skeletal discoveries in the Yuha desert and Salton Sea areas suggest dates of at least 5,000 B.P. (before present time). Both burials possessed grave goods, similar to the San Dieguito III phase as discerned by Rogers' (1958) final typology. However, as noted by Burton (1973) "few samples of the later San Dieguito has been noted in the same area" as the Salton Sea burial. Worn and flat dentition and the lithic assemblages associated with these two skeletal finds suggest a hunting and gathering subsistence pattern.

The San Dieguito cultural complex appears to have been an early population, relatively small numerically, with hunting as the primary subsistence activity. They most likely entered the San Diego coastal area around 10,000 B.P. from the southern Great Basin and continued to

inhabit the area until approximately 8,500-7,500 B.P. at which time the La Jolla complex appeared.

The San Dieguito I horizon was directly associated with the last pluvial. Worked materials deposited by these paleo-Indians is rather scant. Occupation was ephemeral but intensive, resulting in areas of many hundred sleeping circles evidence revealing what may appear initially as an extensive village site. (Photo I-7)

San Dieguito lithic implements and cultural features are marginal to fossil streams and rarely found near lakes. Over 80% of San Dieguito I sites have been found below 1,000 feet elevation and never near present water sources. The chief distribution of San Dieguito I sites occur marginally to dry wash channels of the desert on upper gravel terraces, mesas, and broad desert pavement sectors. San Dieguito I sites have not been found located in association with later cultural material, except rarely. Artifacts are seldom observed near sleeping circles. Over 90% of these clearings are circular, with another 9% being oval and the remainder being rectangular. Many are immediately adjacent to each other suggesting family grouping with duration of occupation being very short (one to three nights). It evidently took a population so few in number several thousand years to build-up the configurations and density observed today. Within those same general areas occupied by San Dieguito people, bouldered-rimmed clearings were constructed by later people such as the Yumans, Papigos, Shoshneans, and Paiutes. Other features of San Dieguito people and those to follow included trail shrines, sacrificial shrines, ceremonial rock abignments, etc.

Artifacts, (i.e., cultural resources), when found in situ, constitute the most valuable historic evidence. In the Colorado Desert over half the area is devoid of San Dieguito I archeological remains.

During the summer of 1973 an archeological assessment was conducted in conjunction with the proposed Geothermal Leasing Program. The following description of the cultural environment in the Salton Sea KGRA, the Glamis KGRA, the Dunes KGRA, and the East Mesa KGRA is presented below.

b. Salton Sea KGRA

In the Salton Sea KGRA only a small amount of land is involved which would be effected by geothermal operations. The small parcels of land taken together compose an area encompassing approximately 2-1/4 sections or 2.25 square miles.

No archeological or historic sites were observed in the Salton Sea KGRA sectors during the 1973 archeological assessment. No isolated cultural remains were encountered.

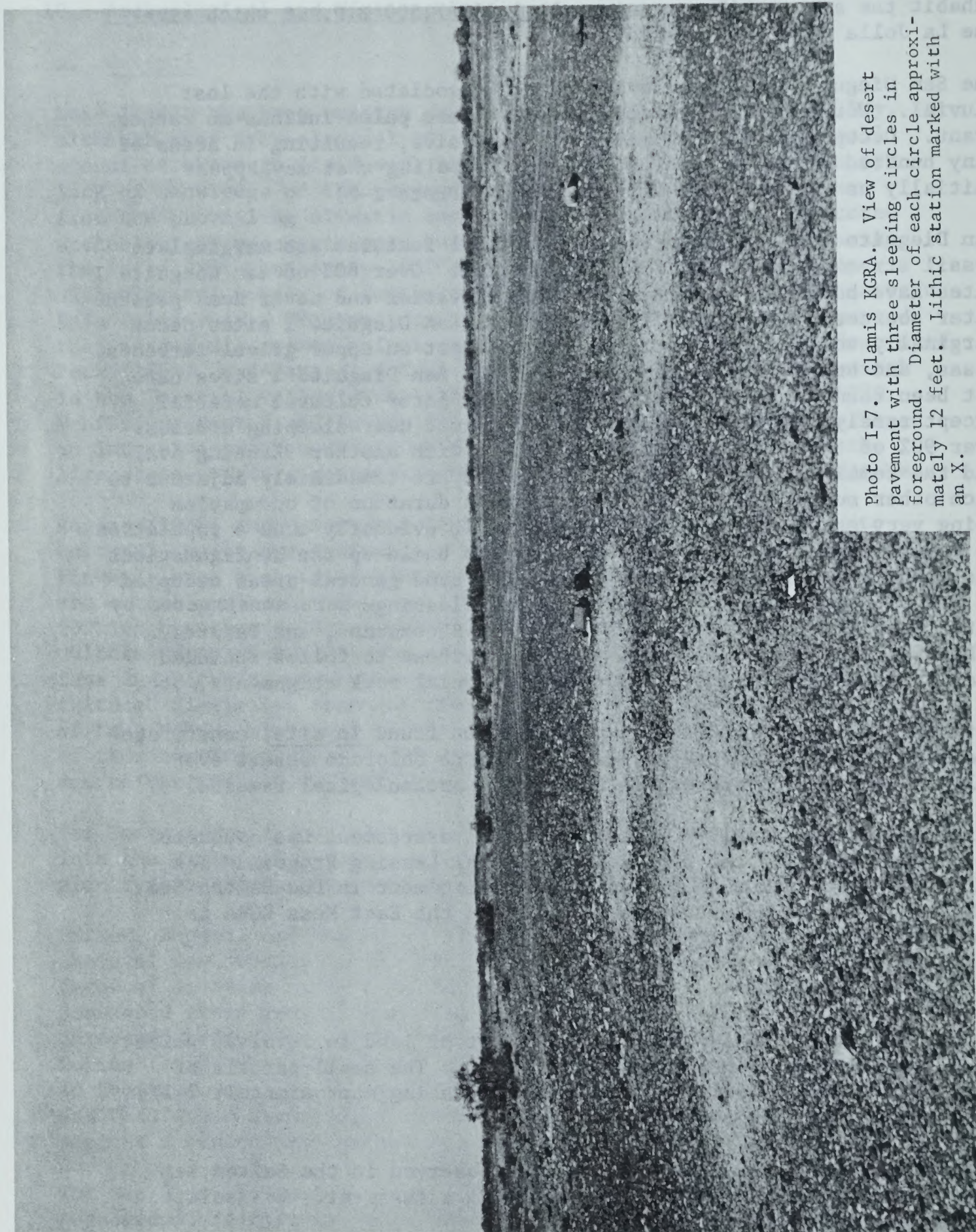


Photo I-7. Glamis KCRA. View of desert pavement with three sleeping circles in foreground. Diameter of each circle approximately 12 feet. Lithic station marked with an X.

c. Glamis KGRA

The Glamis KGRA is an area of high archeological significance. Over half of the KGRA is covered by sand dunes sprawling over an area composing 18 sections.

Eastward, beyond the dunes east of the Southern Pacific Railroad lies an area of great archeological significance. For control purposes the Glamis KGRA is divided into three sectors" Glamis (west), Glamis (central), and Glamis (east). (Figure I-2).

(1) Glamis (West)

Most of this area is composed of low semi-stable dunes and open scrub vegetation. Cultural evidence therein was observed to be minimal at surface level. Cobble-size choppers of quartzite, buff ware, grey ware, and buff with scaling was observed south of highway 78 in section 35 of T. 13 S., R. 17 E.

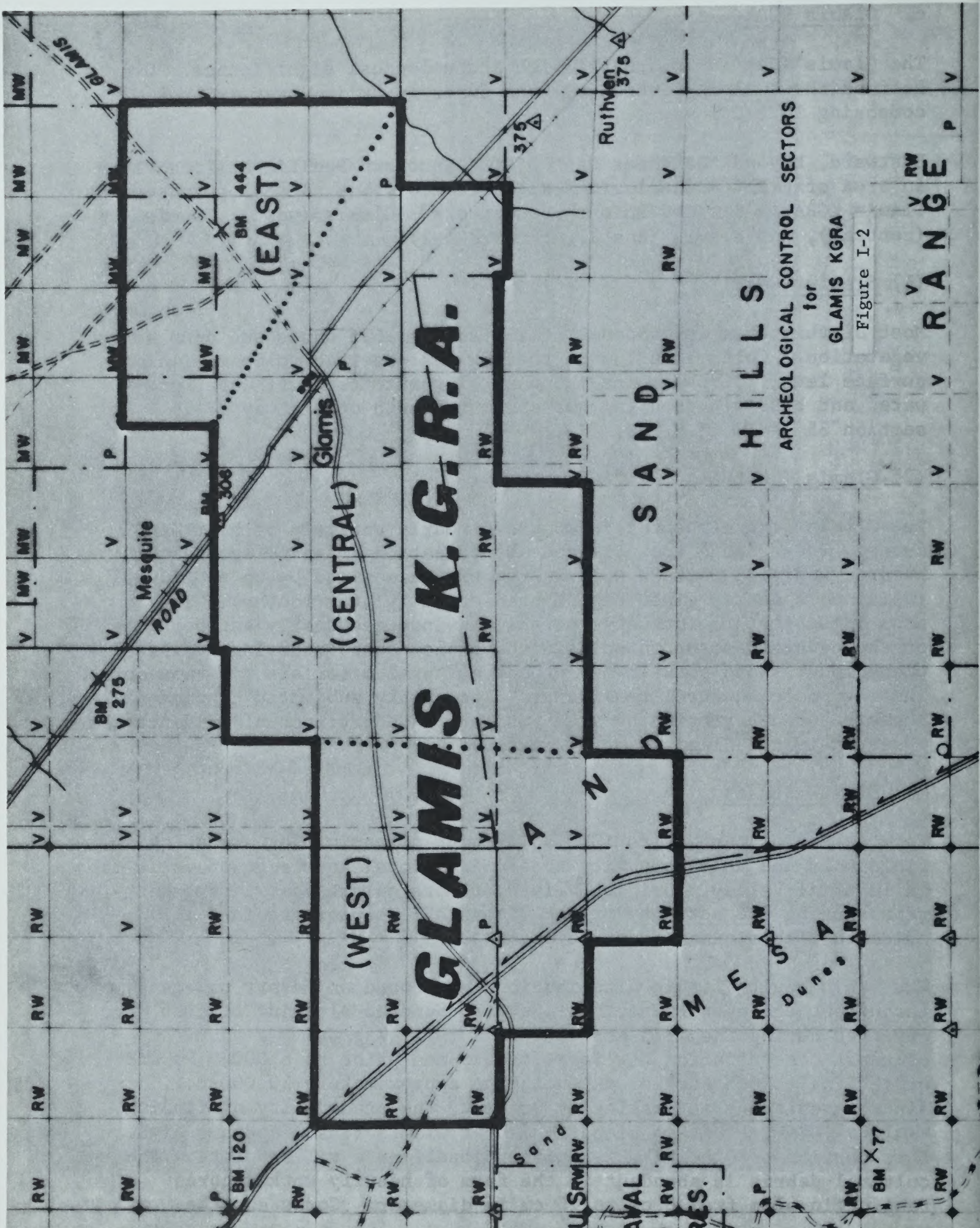
(2) Glamis (Central)

The Glamis central sector is composed nearly entirely of high sand dunes. These dunes are utilized as recreation areas by several hundred individuals each week in the off season and by up to 27,000 individuals on any given day of the season (winter months). The area is subject to intensive northwest winds seasonally and portions of the central sector on occasion have blow-outs occurring at various elevations. Sand pockets may expose cultural materials via blow-outs. These exposed cultural remains are alternately subjected to wind abrasion or destruction by area visitors. No artifactual evidence was observed in the Glamis central sector.

(3) Glamis (East)

This sector of the Glamis KGRA holds high potential for archeological field work and an opportunity to add additional knowledge of early man in Imperial Valley. Original living floors on the desert pavement representing the activity of San Dieguito I peoples are in full evidence with minimal destruction.

The San Dieguito lithic distributions are found on desert pavements throughout the eastern sector. Several hundred sleeping circles were observed during the 1973 assessment. This area was one of heavy concentration for San Dieguito men prior to 5,000 B.P. and quite likely much earlier extending to approximately 10,000 B.P. Although evidence is lacking at present, the probability of finding skeletal remains of San Dieguito man at Glamis (east) appears high. This portion of Glamis KGRA exhibits itself as a village site. The cultural debris is abundant in the form of heavily worked cores ranging in size from 3 cm to 16 cm in diameter. Cores and the



resultant flakes are largely of jasper and chalcedony although other heavily varnished artifacts of volcanic origin occur highly mixed throughout. These chippings stations adjacent to some sleeping circles are largely intact as they were deposited some 10,000 years ago.

Core tools abound on the desert pavement of Glamis east and since many finished implements possess relatively recent (Yuman) modification this area holds a wealth of archeological evidence.

d. Dunes KGRA

The 1973 assessment included an aerial reconnaissance of the area followed by an on-foot inspection. No cultural materials were observed in the accessible sectors. Ninety-five percent of this potential geothermal area is composed of high sand dunes. The remaining 5% of open land, in addition to blow-out areas in the dunes proper, yielded minimal cultural evidence of an archeological nature. Only a few sherds were observed on the surface near the Coachella Canal in T. 16 S., R. 19 E., in the NE 1/4 of section 5. These sherds were thin possessing a buff exterior and interior similar to the Yuman ware noted above at Glamis KGRA. Due to the nature of the shifting sand a site may be exposed one day and completely covered the next by several inches of sand.

e. East Mesa KGRA

For control purposes the East Mesa KGRA was divided into four sectors: East Mesa (west), East Mesa (northeast), East Mesa (south), and East Mesa (southeast). (Figure I-3).

(1) East Mesa (West)

This sector is composed of nearly four townships in the project area, lying between the East Highline Canal and the Coachella Canal. Along the old shoreline from Holtville Airstrip to the southmost point of the shoreline in section 19 T. 16 S., R. 17 E., cultural resources are found mostly out of cultural content. Choppers, chopping-tools, few flakes, beads, and an abundance of pottery sherds. There appears to be no selectivity in lithic source materials. The range of lithic artifacts are made from chalcedony, porphyry, and various other locally occurring nodules found in the Valley. For site localities recently encountered see map. Along the old shoreline culture materials are found to depths of 24" due to heavy usage of the sector for off road vehicles and local gravel quarrying operations. Most of this material is situated in loosely compacted lucustrine deposits with distributional patterns in a state of chaos. On the mesa proper above the shoreline at the 35' contour and eastward, remnants of desert pavement hold distributional patterns in tact at the surface with cultural materials found no deeper than 9 cm. Eastward beyond the 35' contour the desert scrub and mesquite bush appear with a

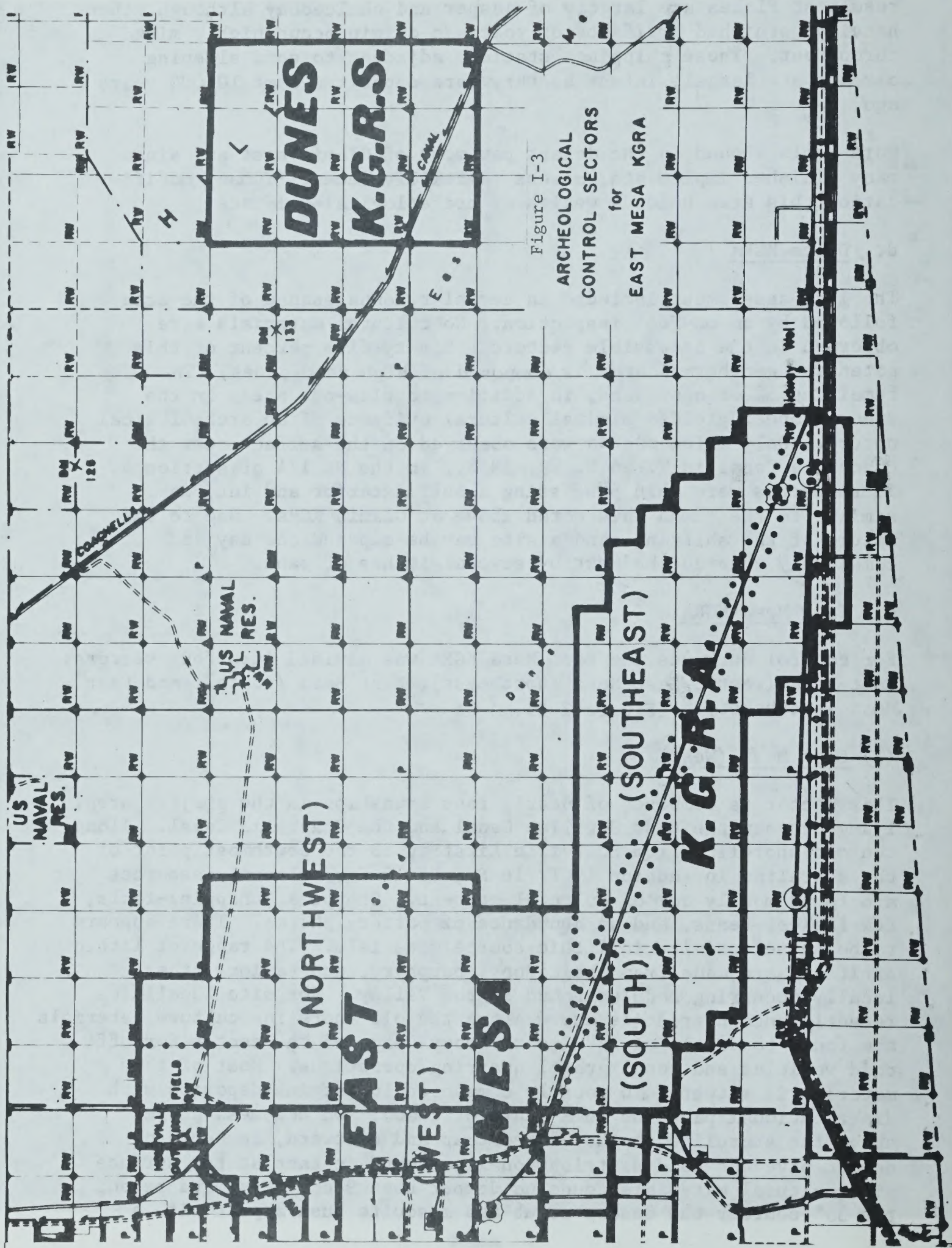


Figure I-3  
 ARCHEOLOGICAL  
 CONTROL SECTORS  
 for  
 EAST MESA KGRA

gradual build-up of silt deposits. However, the 1973 reconnaissance assessed the East Mesa KGRA in its entirety locating sites throughout.

#### (2) East Mesa (Northeast)

Minimal evidence of prehistoric usage was observed in this area, and the primary use by prehistoric man appears to have been for ephemeral campsites. No artifactual evidence whatsoever was encountered in the northern half of the area, which is a rugged inhospitable region with low-lying scrub vegetation. The southern half of the area, however, does contain some campsites; evidence consists mainly of isolated sherds, with no lithic material.

The NE sector has suffered minimum disturbance by modern man. The only significant surface alteration is the military road built in the early 1940's to link the abandoned Holtville field with the abandoned air base in T. 15 S., R. 18 E.

#### (3) East Mesa (South)

This portion of East Mesa was highly utilized during both the prehistoric and the historic eras. Unfortunately, disturbance of cultured resources by modern man in the form of off-road vehicular traffic and gravel operations have destroyed most areas of highly potential archeological sites, especially in the western portion of this sector. Other sites have been partially destroyed by electrical power line installations. This area is second only to East Mesa (E) for artifactual evidence of early man than any other sector of East Mesa KGRA. Yuman occupation is in evidence at every portion south of highway 80. Four extensive habitation sites were located in addition to numerous smaller and scattered sites throughout.

Eleven major sites were located in East Mesa (S) with four considered worthy of nomination to the Federal Register of Historical Places.

#### (4) East Mesa (Southeast)

Concentrations of ceramics in this sector are rather evenly dispersed with a slightly higher density in T. 16 S., R. 18 E. Thick sherds ranging from 4" to 9" in size were encountered. (Photo I-8) No lithic materials were encountered beyond a few (total 8) small quartzite choppers. This sector appears to be mainly composed of ephemeral campsites deposited on alluvial sands. These sites are transitional of people moving from the highlands of the east across the desert to the coastal area. The ceramics indicate Yuman occupation.



Photo I-8. East Mesa KGRA. Typical of Large Yuman ceramic sherd. Typical of pottery found in East Mesa (SE).

## 11. Recreation

### a. Salton Sea KGRA

The Salton Sea is one of the major recreation attractions in Southern California and it represents an important recreation destination to several million visitors each year. There are very few areas which can accommodate the enormous numbers of people in the Southern California area who want and need a place to spend leisure time--the Salton Sea is one of those. It offers relief from city congestion; it is conveniently located; it has warm and clear weather in the fall, winter, and spring.

A wide variety of recreation activities are popular at the Salton Sea including: fishing and hunting; pleasure boating; water skiing; power boat racing; swimming; photography, sight seeing; camping and picnicking; nature study; and off-road vehicle use. The size of Salton Sea (230,000 acres), its elevation (234 feet below sea level in 1967) its climate, and its location, all contribute to its importance as a unique recreation attraction.

The Salton Sea, with its unique characteristics, is a major regional recreation attraction and possibly a national one. Many elements of resource environment are extremely fragile and quality is steadily deteriorating due to the high initial salt content of the water body, its very high evaporation rate (5 feet per year), and the approximate 4.4 million tons of salt deposited in the lake each year from surrounding agriculture land.

Most of the Federal lands within the Salton Sea KGRA, are under water. Of the 357,000 visitor days of fishing occurring each year in the Salton Sea, about 35,000 visitor days of "general recreation" (non-angling), about 13,000 visitor days occurs within this KGRA. In total, about 48,000 visitor days of recreation use take place within the Salton Sea KGRA.

It is estimated that it costs about \$15.00 for each visitor day including recreation equipment, transportation, food, beverages, lodging, etc. Based upon this cost, the annual value of recreation on the Salton Sea proper would be in excess of \$11,000,000. Proportionately, the KGRA area value would be \$720,000 per year.

### b. Glamis-Dunes KGRAs

In 1972 the Secretary of the Interior formally designated 252,000 acres of the Imperial Sand Dunes as Recreation Lands. Earlier, portions of the Dunes were registered as a National Natural Landmark, and there is a pending proposal to establish an 18,000 acre natural area near Highway 78.

The interest of scientists, recreationists and conservationists, in the Dunes' unique ecological and scenic attributes has been described in previous sections of this document. To illustrate the massive public appeal generated by those attributes, the following visitor use data has been compiled from BLM studies over the past five years:

During the heavy use season (September-May) four-day holiday weekends represent peak visitor concentrations. In 1970, Thanksgiving weekend counts showed 7,335 vehicles - more than 25,000 people. Over the New Years weekend of 1971, a total of 5,635 vehicles were present with nearly 20,000 people engaged in recreation activities. Estimates for Thanksgiving, 1972, and New Years, 1973, are 8,000 vehicles (32,000 people) and 6,000 vehicles (24,000 people) respectively. In addition to these peak periods, Easter and several other major three day weekends, regular weekends, and weekday use combine to a total of 1,500,000 visitor use days annually in the Imperial Sand Dunes. This visitor use accounts for recreationists who travel primarily from the Los Angeles and San Diego metropolitan areas. The dunes are their prime destination, and these people remain there for the duration of the trip. Their primary activities are off-road vehicle use, camping, sightseeing, and similar leisure often described by the people themselves as "just gettin away from it all." (Photos I-9, I-10, I-11) Public use in the dunes is characterized by its unregimented, informal nature. Visitors generally come and go as they please, camp where they please, and recreate as their interests dictate. The use figures do not include transient sightseers who drive along Highway 78 and Interstate 8. Traffic counts in 1972 showed average daily traffic on Highway 78 as 2,500 vehicles, and 7,500 vehicles on Interstate 80. The sightseeing visitor use data for these traffic flows have not been thoroughly analyzed and few figures are available. The Imperial Sand Dunes Management Plan (BLM, 1971, page 8) indicates; however, that approximately 2 million non-ORV users viewed the dunes from the highways in 1971.

Bureau of Land Management studies indicate that average expenditures per visitor use day is \$2.57, or nearly \$4,000,000 annually for food, gas, repairs and incidental expenses encountered per trip to the dunes. This figure does not include recreational equipment or other major expenditures. The Imperial Sand Dunes Management Plan explores recreation aspects in detail. Included are background data on all forms of public use, socio-economic profiles, analyses of a complexity of management objectives, and long range development goals. Acreages within the Glamis KGRA are particularly discussed. The KGRA encompasses the area of heaviest visitor concentrations, part of the natural area that has served as convenient and unique outdoor education and research site for scientists since 1955, and pivotal user contact and dispersion developments explained in long range plans. For instance, the dunes scenic road begins at Highway 78. About three miles have already been constructed, with a series of camping loops at the terminus. Ultimately, the road will extend down the Dunes' west side through the Dunes KGRA, all the way to Interstate 80. In addition to the scenic road, plans call for two administrative areas with support



Photo I-9. North End of Imperial Sand Dunes -- Glamis KGRA.  
Looking west along State Highway 78. Every available  
pull-off harbors a dune buggy enthusiast.

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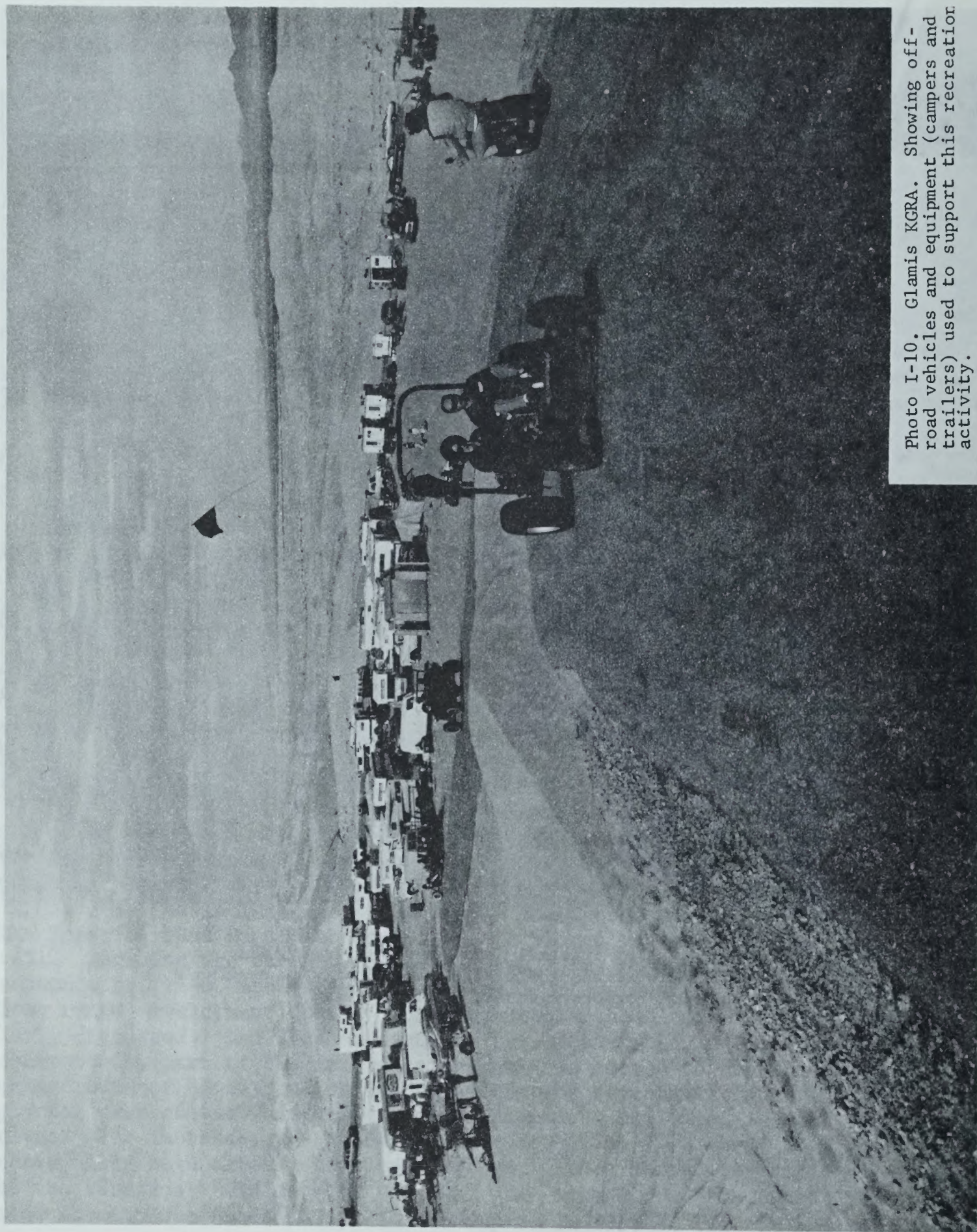


Photo I-10. Glamis KGRA. Showing off-road vehicles and equipment (campers and trailers) used to support this recreation activity.

Photo I-11. Glamis KGRA. Dune area showing concentration of dune buggies on this particular day. Note scarcity of vegetation.



facilities for public use management, eight developed camping areas, a visitor center, access roads, and wayside exhibits, Osborne Park on Highway 78 is already in existence and is a prime user concentration point. The Dunes KGRA encompasses another concentration point where users convene, camp and disperse in the dunes via ORV's. There is an existing access road and camping use is heavy in the south third of that KGRA.

c. East Mesa KGRA

Recreation use in this KGRA is limited, generally, to occasional organized off-road vehicle events. The area has little appeal for hunting, camping or rock collecting. Because of the proximity of the dunes and other choice recreation areas, the East Mesa KGRA receives only nominal public use. There are no existing or planned recreation developments.

12. Minerals

The only significant mineral resources occurring in any of the four KGRA's are sand and gravel deposits. In the Glamis KGRA, sand and gravel deposits occur in the northeast portion of the area, northeast of the railroad tracks. The remainder of the area contains only dune sand. In the East Mesa KGRA, sand and gravel deposits follow the ancient beachline of Lake Cahulla along the western border of the area.

The sand and gravel presently being mined from these KGRA's is used primarily in the mixing of cement and for road construction purposes.

In the Salton Sea KGRA, the pumice and rhyolite of the Salton Buttes have been quarried extensively.

### C. ENVIRONMENTAL IMPACT OF PROPOSED ACTION

A comprehensive discussion of potential environmental impacts associated with the development and use of geothermal resources is included in Volume I, Chapter III, Section B of this impact statement. Such discussion will not be repeated here except to the extent such is needed as a basis for evaluation of specific impacts within the Imperial Valley KGRA's.

Since the degree of potential environmental impacts of the proposed geothermal leases generally would be directly related to the proportion of Government to private land ownership, to the type of resource (hot water/or dry steam), the status of private land resource development, and the probable sequence of geothermal operations, appropriate discussion of land status and the possible nature and sequence of geothermal operations is presented here for the Salton Sea and East Mesa KGRA's.

#### Salton Sea KGRA

The Salton Sea KGRA consists of 95,824 acres, approximately 50 percent of which lies underwater within the present Salton Sea lake bed. (Refer to Figure I-1 and enclosed large-scale map). Onshore, more than 95 percent of the land is under private control, with only scattered Federal acreage in the northern end. Offshore, less than half the lake bottom is federally controlled, and a portion of that is wildlife refuge or Navy seaplane landing areas or mine laying areas. In addition, some of the Federal offshore lands are in dispute with the Imperial Irrigation District as to ownership. All of the present geothermal discoveries are in the southern third of the KGRA. All are onshore and on private lands. Federal land holdings are primarily in the northern offshore portion of the KGRA. Leasing of Federal lands would be by competitive bid, with appropriate provisions for those lands subject to qualified "grandfather clause" applications.

If Federal lands are leased, the major activity would occur offshore, in the northern half of the KGRA. Since no exploratory wells have been drilled in the lake bed, or in the northern onshore portion, geologic and geophysical work and test drilling would have to be performed to prove the existence of the resource. In the reconnaissance stage, geophysical work would probably consist mainly of water-born test equipment, not involving the use of explosives. Shallow temperature holes 100-500' deep may be required for heat flow information, drilled with moderate sized rigs barge-mounted.

The exploratory test phase would require holes 1000-10,000' deep, drilled with modern oil and gas type rigs using constructed steel platforms, either floating or submerged barges, or man-made land-fill islands. Access to the offshore drill site would be by boat, pier, or rock causeway. Generally, drilling conditions, safety precautions, and hazards would be similar to onshore locations. Water depths are moderate, ranging

to a maximum of 40 feet and averaging approximately 30 feet. Thousands of oil and gas wells have been drilled under similar conditions.

Production testing produced water and steam might be transported ashore to either holding ponds or injection wells. Assuming very high salinity brines (250,000 ppm +) would be encountered, as with existing onshore wells to the south, special precautions would have to be taken to prevent spills or water pollution. If the water quality and expected test volumes were such that the lake water quality would not be harmed, test waters might be released directly to the lake. Offshore injection wells might also be drilled for water disposal during the test period. Such factors will be specifically considered and set forth in lease provisions and for GRO orders.

Large-scale development of the offshore Salton Sea KGRA would require a comprehensive geologic and engineering study encompassing both Federal and private lands. This would be necessary since Federal and private lands are mostly "checkerboarded," with very few areas of sufficient single-owner size to allow separate development. Development drilling would probably be from central platforms (approximately one per square mile), with the wells directionally drilled. The drill sites could be either from drilling platforms (similar to offshore Louisiana oil and gas production), or from man-made islands (similar to the THUMS Long Beach Harbor Islands). Access to these islands could be either by boat, pier, or rock causeways or dikes. The whole development would have to be carefully planned as an overall, integral operation, to allow proper solution of the many problems which would arise. In all probability, private and Federal lands would be unitized.

Generating and by-product plants might be constructed either on shore or at the drill sites. Since the water depths are relatively shallow (30' +) it is not inconceivable that dikes could be built around the sites, and wells and plants be placed on the lake bottom. Hot water or steam pipelines could be layed under-water, or on the access piers or causeways. Electric transmission lines might follow the same routes.

The end result of full scale offshore development and production would be a number of offshore sites, possibly one per square mile, with access either by boat, piers or causeways. Noise would be moderate and potential air pollution a distinct possibility. Mishaps from pipe line breaks or blowouts could temporarily locally increase the lake salinity to undesirable levels. Waste brine would probably have to be injected to prevent undesirable salt buildup in the lake, and to prevent subsidence. Subsidence, if occurring in the lake bottom, would not have nearly as serious consequences as in the onshore agricultural area.

## East Mesa KGRA

The East Mesa KGRA consists of 38,365 acres, of which approximately 90 percent is Federal land. All of the Federal land is under Bureau of Reclamation Withdrawal, and cannot be leased unless the Bureau of Reclamation considers such action as being compatible with the purpose for which the land was withdrawn and with current Bureau programs in the area. All leasing would be by competitive bidding.

The Bureau of Reclamation is currently conducting tests in the East Mesa KGRA to determine: (1) does a significant geothermal resource exist, and (2) can this resource be utilized to provide large volumes of desalted water for the southern portion of the Colorado River irrigation.

The Bureau of Reclamation has conducted extensive geological and geophysical exploration in the area, and has drilled one deep exploratory well. Several more shallow temperature holes are scheduled, and another deep (6000') well was spudded in July, 1973. If lands were to be leased to private industry, further exploratory tests wells would probably be drilled - some in the general vicinity of the initial Well G-1, and others to the south and east.

Full scale development drilling and generating and/or by product plant construction would depend on results of the exploratory and production test program. Full scale commercial development would result in construction of well systems, electricity generating plants, and possibly desalination plants if fresh water is to be produced. A Bureau of Reclamation proposal for combined power and water production operation, envisions approximately three plants per square mile. The overall project would include surface disturbance for roads, well sites and plants. Pipe lines would be needed to transport hot fluids and desalted water from the plants. Transmission lines would be required within the field and to the point of electricity use. Noise would be minor. Air pollution is a possibility. Waste fluids probably would have to be disposed of by injection, primarily to prevent subsidence in adjacent farm lands. Make-up injection water to replace produced volumes would have to be brought in from some outside source, cooling tower water requirements also would have to be met from external sources.

## 1. Description of Impacts

### a. Resource Reconnaissance Stage

Reconnaissance for geothermal development includes a variety of field activities such as geologic mapping, magnetic, electrical and seismic surveys, and shallow drilling. Much of this preliminary work has been done in the KGRA's of the Imperial Valley and it is expected that future exploration of these areas will entail deep drilling activities. These activities can be expected to be confined to many small areas in each KGRA, requiring additional access road systems.

The major impacts on the environment of this activity will be damage to vegetation, disturbance of archaeological sites, and aesthetic degradation. Vegetation may be destroyed as new roads are established to allow access for drilling equipment. Archaeological sites displaying surface materials and artifacts may be disturbed and the scientific interpretive values damaged or lost. Intra-site proximity patterns and general distributional arrangements of artifactual evidence may be destroyed by drilling, construction of access roads, and general geothermal site development.

### b. Test Drilling and Production Testing Stage

#### (1) Water Resources

##### (a) General

Extraction of geothermal brines in the Imperial Valley, including brines that contain dissolved solids ranging from one to five times the concentration in sea water, whether for exploration, development, or production, poses a threat of contamination to soil, ground water and to the Salton Sea. The impact on water resources of geothermal exploration, drilling, and production testing to date probably has not been significant. One geothermal well drilled in 1962 discharged saline brines to the Salton Sea for a period of 90 days during which 250,000 tons of salt were contributed to the Sea. This represented an increase of 4.5 percent in the dissolved mineral contribution to the Sea for that year.

The possibility of spilling quantities of brine at the land surface or of blowouts in wells releasing quantities of brine to parts of the aquifer system other than those from which the brines originate exists during drilling, testing, and operation of geothermal wells. Abandoned and active geothermal well sites in Imperial Valley include temporary holding ponds for each well. The ponds and well heads are potential sources of spills that could result in the application of quantities of saline water at the land surface to the detriment of other uses of the soil. Infiltration could degrade ground water at the water table. Subsurface leakage due to blowouts and casing failures could result in injection of hot saline water into zones of cooler and less saline water. Subsurface injection may not

be critical because the receiving water may not be suitable for most uses. However, the prospect of injecting a water solution of perhaps 30,000 parts per million dissolved solids into a section containing water of 4,000 - 8,000 parts per million dissolved solids suggests that degradation of the water in the aquifer containing the lower concentration could occur. Subsurface contamination of ground water could impact the availability of ground water for cooling or render some other future use of the water impossible.

(b) Salton Sea KGRA

The environmental impact of spills or blowouts from geothermal wells in the Salton Sea area could be detrimental to both surface and ground water resources. Accidental discharge of hypersaline fluids (20-30 percent salt content) to the Salton Sea could significantly alter the inflow and the salt load in the Sea. Water spilled onto the land surface shoreward from the Salton Sea could cause accumulation of salt at the surface and contribute to degradation of water quality in the water table aquifer. Subsurface casing failure could allow injection of hot, hypersaline fluid into overlying aquifers causing degradation of the chemical quality of water and increased temperature in the injected zones.

(c) Glamis, Dunes and East Mesa KGRA's

The environmental impact of spills and blowouts in the Glamis KGRA probably will not affect the Salton Sea but could have some significant local impact. Photo I-12 shows the use of a plastic lined holding pond at the Bureau of Reclamation East Mesa test site. Infiltration is prevented and waste waters are allowed to evaporate. Sandy material exposed at the surface in much of the KGRA's will permit rapid infiltration of fluids. Subsurface blowouts or leaks in well casings would result in transfer of fluid from one aquifer to another. If the receiving aquifer in such a transfer contains water of better quality than the supplying aquifer, then water in the receiving aquifer will tend to be degraded - the extent of degradation depending upon the quantity and quality of the injected fluids.

The chemical characteristics, temperature, and quantity of ground water in the area have not been explored in sufficient detail to evaluate the importance of spills and blowouts on the ground water environment in the area.

Water samples from test well Mesa 6-1, in the East Mesa KGRA, contained dissolved solids concentrations of about 30,000 mg/l at about 107° C (U.S. Bureau of Reclamation, 1973, p. 29 and 33). Water in overlying aquifers contains appreciably lower concentrations of dissolved solids though not in the range described as useable for most purposes (California Department of Water Resources, 1970, pp. 59-68). If water like that from Mesa 6-1 were infiltrated to the water table or injected into overlying aquifers, degradation would occur. The magnitude of degradation probably is not

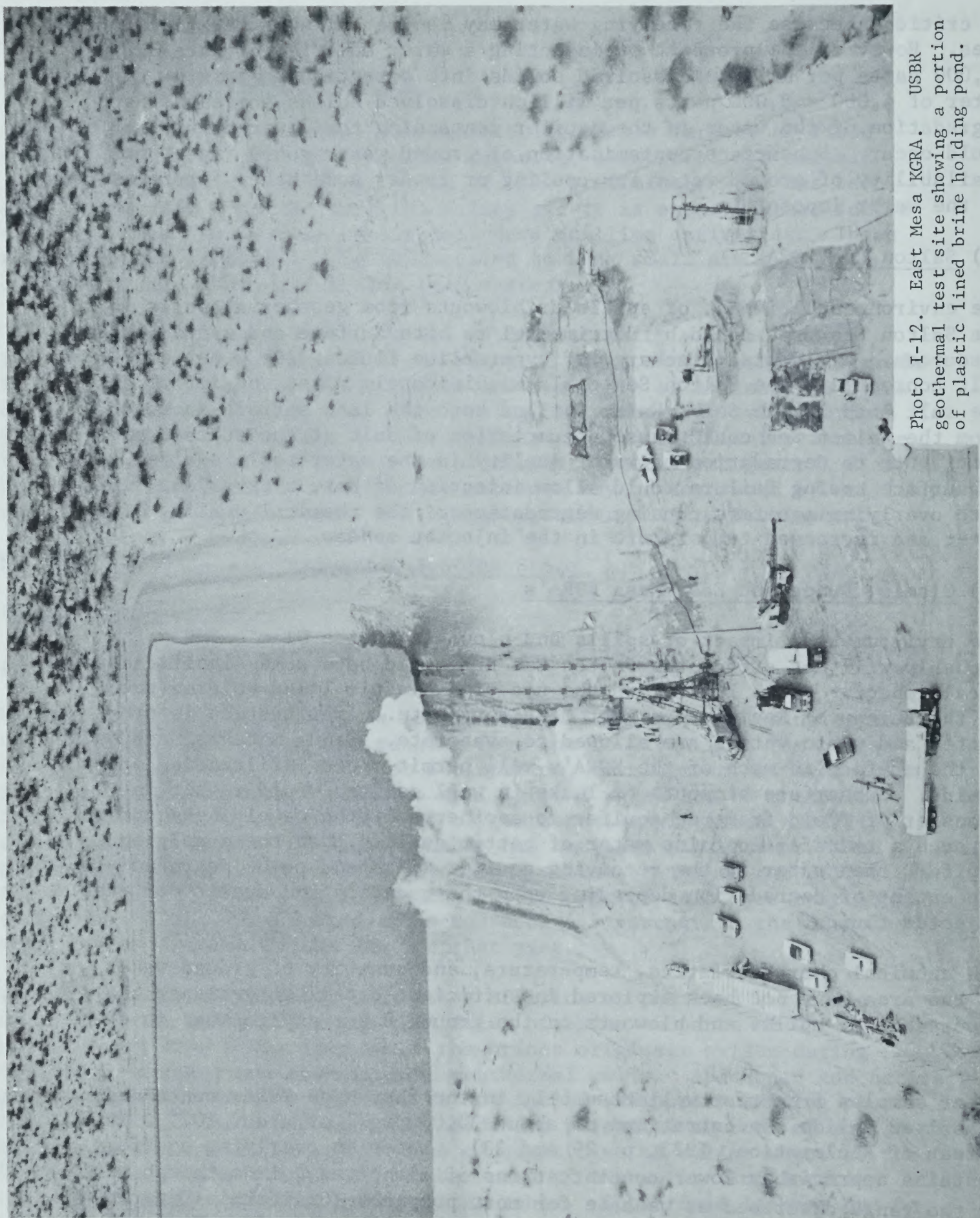


Photo I-12. East Mesa KGRA. USBR  
geothermal test site showing a portion  
of plastic lined brine holding pond.

significant if yields of additional wells in the East Mesa area are similar to that of Mesa 6-1 (250 gpm). However, if large yields of commercial development are feasible, potential impacts would relate the magnitude of such yields.

## (2) Noise

Geothermal well drilling in the Imperial Valley area has been accomplished with mud circulating systems. Noise generated from the drilling operations falls within acceptable standards issued by Imperial County. In close proximity to areas of high population density, however, noises emitted by engines, connecting of pipes, and unloading of supplies may be objectionable. Drilling operations generally last around the clock about 30 to 45 days for each well. Production testing of wells, in which 20 to 25 percent of the fluids flash to steam, generally does not exceed 90 days. The noise of the expanding steam, if not muffled, would be comparable to the noise of an unmuffled diesel truck, as discussed in Chapter III, Volume I.

In general, the noise pollution generated during the drilling and testing phases of the operation could degrade the environment for recreation use.

## (3) Vegetation

### (a) Salton Sea KGRA

Construction of access roads, test well sites, borrow areas, and brine pits would destroy some vegetation. The construction of islands might allow vegetation to remain relatively undisturbed in the area of the sea; however, vegetation in borrow areas selected for shoring and stabilizing the islands may be destroyed. Revegetation of these areas would be difficult because of the desert environment; however, native vegetation should reestablish itself in time. If the salinity of the Salton Sea were to increase, vegetation in marsh areas would change. Vegetation would decrease, less tolerant species would be stressed, and specie populations might be unable to maintain themselves; however, this may occur without development of geothermal resources, as increasing salinity is becoming a major factor as previously discussed.

### (b) Glamis KGRA

Road construction, drilling and other associated activities may have a detrimental effect on the vegetal communities within the Glamis KGRA. Those areas that would be most effected include the Bajada community on the eastern edge, the creosote forest community adjacent to the Coachella Canal, and the seeps associated with the Coachella Canal along the western edge of the KGRA.

Surface disturbance includes preparing areas for drill pads, drilling mudponds, and blading roads. Vegetation which will be most effected are the shrub or woody species. Each of the shrub communities within the Glamis area are well developed and support mature plants, many of which are over a half century old. Some of these mature plants could be destroyed. Replacement of the perennial vegetation on these disturbed sites would require many years following surface disturbance.

Extensive exploration would also pose an additional impact on these plant communities. Not only would individual plants be destroyed or damaged, but the natural aspect of the communities could be altered. Under the natural conditions which currently exist over much of the area, the bajada and creosote communities are fairly uniform throughout. Clearing areas or opening up the shrub canopy would result in an altered vegetative aspect, by lessening the vegetative density. The bajada community includes a moderate to well developed desert pavement which is partially responsible for holding soils in place. There is very little movement of sand and soils within this community except where there has been recent disturbance. This impact may be of a short duration, as a desert pavement might be reestablished within two to three years after disturbance provided the materials have not been removed from the site.

Chemical contamination of sites may result from test drilling in all of the basic communities within the Glamis KGRA. It has been noted that much of the geothermal fluids found within this area are extremely saline. If these fluids were dumped onto the ground surface the vegetation in that area could be lost. Eventually these salts could be leached from the site. However, because of low annual precipitation (less than 2 inches) leaching would take many years.

#### (c) Dunes KGRA

The impacts on vegetation from test drilling and production testing on the Dunes KGRA would not be as noticeable as that on the Glamis area. Vegetation within the dunes is sparse and large interstices exist between perennial plants. The general aspect of the community would not be altered extensively and the shifting sands common to this area would soon remove signs of the surface activities. Contamination of the drill sites could occur. Natural leaching of contaminants would be a slow process.

Surface activities may disturb the sparse creosote community. The removal of vegetation would not be significant in the Dunes KGRA. Disturbed sites are subject to "blow outs" in which sands and soils are lost from the site through wind displacement; however, this problem could occur on the presently more stable soils found in areas within the creosote community.

#### (d) East Mesa KGRA

The two basic communities, creosote and dunes, within this KGRA would be moderately effected by test drilling and production testing. (Photo I-13)

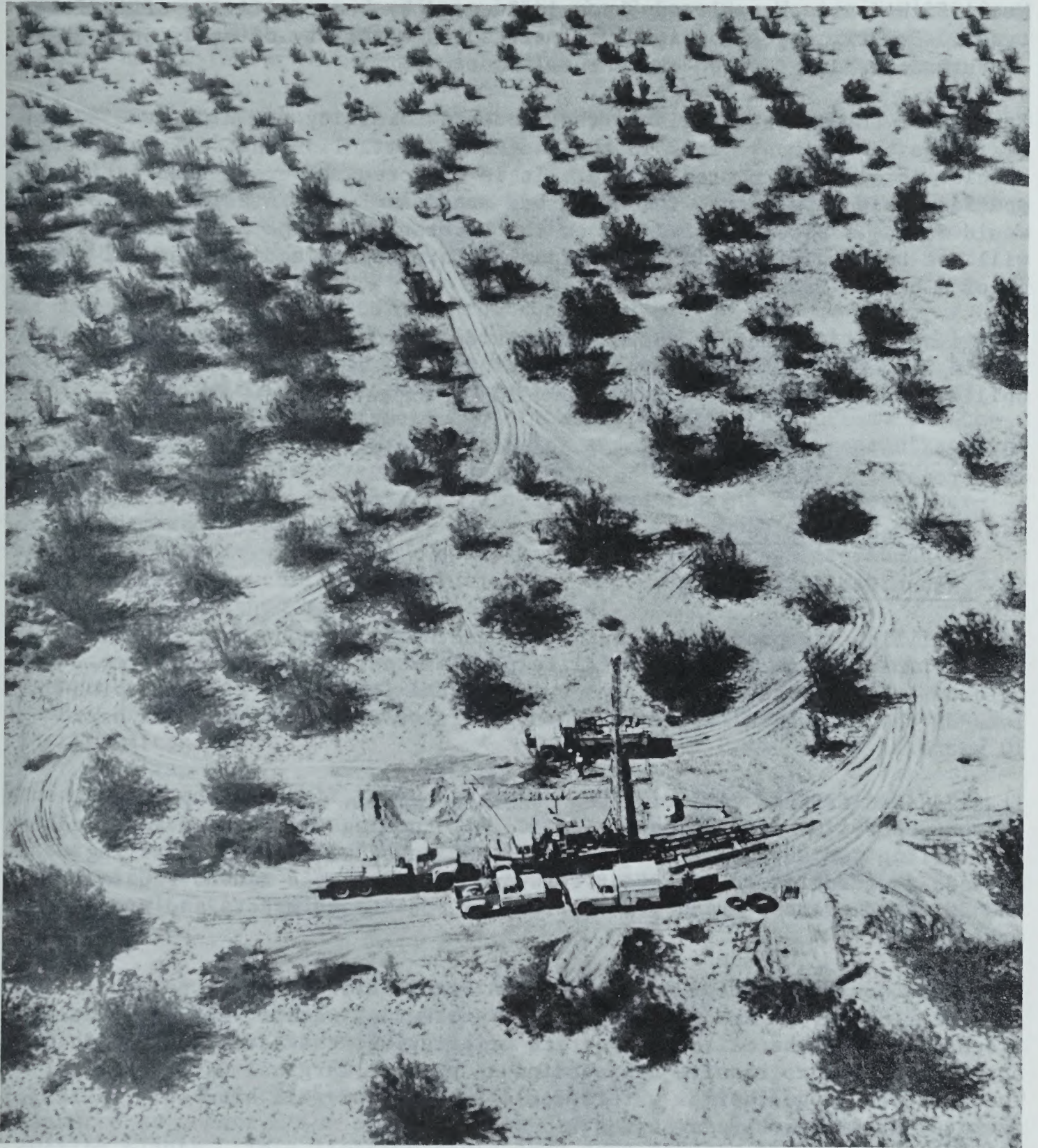


Photo I-13. Creosote Community--East Mesa KGRA. Drilling Activity of USBR in 1971. Note the minimal disturbed vegetation.

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Much of this area has already been influenced by human activity of various types. Powerlines, airstrips, well sites and a variety of other surface disturbances have changed the natural setting.

Removal of shrub species within the creosote community can alter the aspect of that site for many years in that natural reestablishment of these woody species is slow and unpredictable. It is expected, however, that native species would expand into the disturbed areas and that invasion of exotics would not be a problem. Impacts on the vegetation of the dunes community will not be significant in that perennials are sparse and the general aspect is of a barren nature.

Contamination of sites by geothermal fluids could be significant especially within the creosote community. Vegetation would be lost where fluids are spilled on the ground. Natural leaching is expected to be slow.

Refer to Volume I, Chapter II for broader descriptions of the vegetation resources.

#### (4) Fish and Wildlife

##### (a) Salton Sea KGRA

Test drilling and production testing of geothermal resources could have varied impacts upon fish and wildlife populations. Such impacts are particularly hard to anticipate in view of the increasing salinity problems of the sea which may result in significant changes within the next 10 years.

It also is difficult to define the specific impacts resulting from this type of operation without more specifically knowing the acreage involved in drilling and support activity, the location of well sites, drilling methods in relation to important fish and game habitats and to Federal and State Management Areas. However, some potential impacts and problems are evident.

The major source of water for the Salton Sea is irrigation waste water. If significant volumes of highly saline geothermal waters were accidentally discharged into the Salton Sea or its tributaries, the additions would accelerate the progressive degradation of present marginal water quality. The addition of geothermal waters could result from well blow-out, spills, seepage, or improper reinjection techniques.

The major potential impact upon fish and wildlife habitat would result from geothermal brines. Physiological stresses placed on organisms within the fishery food chain as well as those placed on fish eggs, larvae, young fish, and adults by higher salinity levels would adversely affect the fishery. At some higher level of salinity, on or more of the links finally would break down. At this point, the fishery would gradually or suddenly be lost, depending on the link that is broken.

The adverse impacts that could result to the Salton Sea National Wildlife Refuge, Wister Unit, drainages, or ponds include alteration of fishery habitat and waterfowl nesting and feeding within the area of influence.

Adverse impacts would result if toxic substances, such as boron, arsenic, fluoride, or zinc, were present in spills.

Accidental releases of heated effluents to waters of the area would alter aquatic habitat and life, perhaps creating temperatures intolerable to fish in the Sea.

If injection water was obtained from local sources or from the Sea, changes in water quality of the Sea could be expected. Should a development involve construction of water storage or salt recovery ponds or the injection of Salton Sea water into geothermal wells, it could have both hazardous or beneficial impacts upon fish and wildlife resources. If the produced water was of acceptable salinity and free of toxic concentrations of pollutants and disease-producing elements, benefits might occur in the form of increased water quality and nesting and feeding areas for waterfowl and marsh birds. However, water above 36,000 ppm dissolved solids would not benefit waterfowl. Use by waterfowl of waste water disposal pond water having toxic concentrations of salts and other elements could result in diminished health of the waterfowl.

Physical modification to the sea and land surface could occur. Impacts on fish and wildlife resources might be caused by road construction, brine ponds, drilling sites on islands and/or drilling platforms, and causeways in the Salton Sea.

The impacts could result in loss of fish and wildlife, natural habitat, and human use within the area of influence. Modification could physically alter or remove existing fish and wildlife habitat. The permanence of these effects would depend upon the location and nature of the particular operational activity and the completeness of control measures or mitigation features.

Use of borrow areas to obtain material for island construction, causeways, and supports for pipelines to production plants could destroy vegetation and displace associated wildlife.

Lighting would be required to support nighttime construction, security measures at construction sites and temporary storage facilities, and production plants. This lighting could have some adverse effect if it should divert wildlife from their natural feeding, nesting, and escape cover.

In addition to sea or land modification, noise and other disturbance could have displacement effects upon animals and birds in the site vicinity. The degree and permanence of displacement or disturbance would depend upon the scope and type of activity. For example, noise from testing wells could have a disturbing influence upon animals within the sound range vicinity of the site.

(b) Glamis KGRA

Test drilling and production testing activities will have varying effects on the wildlife resources within the Glamis KGRA. Those species which will feel the greatest impacts are associated with the creosote forest, the bajada and seep vegetal communities. There also is the potential to disturb or destroy specific sites used by such species as the western diamond back rattlesnake, spade foot toad, and the desert tortoise. These species have traditional sites used during periods of inactivity. Snake and tortoise dens are used generation after generation, and may be as old as 1000 years or more. Road building and site clearing could destroy such areas used by these species. While none of these specific dens have been identified in this KGRA, it is known that these species do inhabit the Glamis area.

The spade footed toad has been identified in two locations in the north-eastern portion of the KGRA on what is known as the sinks. Loss of these sites could eliminate the toads within these areas. The sinks are fairly large depressions which collect water during heavy storms, at which time the toad becomes active. Disturbing these sites either by drilling or allowing toxic fluids to enter the depressions where the toads are encapsulated could destroy them. Removal or displacement of surface soils from these sites could also be detrimental to these spade foot toad populations.

The creosote forest associated with the Coachella Canal offers desirable habitat for a variety of desert species. Extensive surface disturbance of this habitat would alter its character and could result in the upsetting of a delicate biological complex. Road building, drilling and associated activities could eliminate much of the current wildlife use of this community.

The social impacts of development and associated activities on wildlife populations should also be considered, although these influences are poorly understood. Certain species of animal life will not tolerate the continuous presence of human beings. Noise and human occupancy may have a detrimental effect of certain species of animal life. However, much of this area is used by thousands of people as a desert playground, and any social wildlife impacts that may be felt from the presence of people may have already taken their toll. The addition of geothermal exploration, at least in those areas currently impacted by people, would probably not be of significance.

Other areas which could be damaged by exploration are the small seeps associated with the Coachella Canal. Drilling activity near these sites could effect the use of the area by terrestrial forms of wildlife which rely on this somewhat unique habitat for food, cover and water. The aquatic systems supported by these sites could be impacted, especially if contaminants of any kind were to enter these ponds.

(c) Dunes KGRA

There is very little wildlife information available on this KGRA, however, impacts from test drilling and production testing could be expected to be minimal. The habitat consists of sparse vegetation, shifting sands and extreme heat, during much of the year and the area does not support an abundant fauna. The major impact that could be felt would be on den sites of the western diamondback rattlesnake and the desert tortoise. However, it is not known at this time if these species have established sites in the area. Habitat alteration of this area by development would not be critical.

(d) East Mesa KGRA

Impacts to the wildlife of this area would vary with the habitat types and wildlife species. The dunes community and its associated habitats would be least impacted by geothermal test drilling and production testing. Vegetal disturbance would be expected to be minimal within this habitat type, and the major influence would be felt on the specific sites selected for drilling and production testing these areas occupied by access roads. No specific sites associated with the rare desert tortoise and the western diamondback rattlesnake, have been noted although both species can be found within the area.

The creosote vegetal community and its associated habitats would be somewhat altered. However, this area does offer an extensive creosote or desert shrub habitat and healing of specific disturbed sites within this community appears to be slow but complete, provided surface soils are not removed from the site or contaminated. Local impacts will be felt by individual ground squirrel populations associated with creosote bush mounds. These colonial rodents are wide-spread and currently believed to be high in their population cycle and the localized loss of habitat or individual animals should not be significant when considering the total population.

(5) Aesthetics

(a) Salton Sea KGRA

The scenic qualities of the area could be disturbed as a result of geothermal developments. The well sites, power plant, pipelines, and transmission lines would be intrusions adversely affecting aesthetics of a natural area. Some people would consider geothermal development a unique attraction and an addition to the scenic and interest point qualities of the area. The development of geothermal steam for electrical energy production is unique at this time and many people would enjoy having the opportunity to see such an operation. Objectionable odors might detract from enjoyment of the area.

(b) Glamis and Dunes KGRA

Test drilling and production testing could alter the aesthetic quality of the dunes. Noises would be introduced, which could be objectionable to campers, sightseers, hunters, nature study enthusiasts and other classes of users. Objectional odors could affect not only the vicinity of the site, but also

broad acreages. Drill rigs, capped wells, roads, ponds, and gaseous, liquid and precipitant wastes would be visible. The facilities associated with geothermal development would sharply contrast with the natural curves and formations which are pleasing to the eye. (Photo I-14) Other considerations regarding both aesthetic and recreation values are the potential adverse impacts of mishaps such as unchecked flows or steam and water or gases.

#### (c) East Mesa KGRA

Test drilling and production testing could cause adverse visual, olfactory, and audio impacts. Some motorist along Interstate-8 might find introduction of man-made structures in the area objectionable, but most would pay scant attention because of the relative drabness of this particular landscape. Flat topography and scarce vegetation would allow structures to be seen from considerable distances. Odors could be unpleasant to transient motorists. Mishaps such as uncontrolled flows of steam, water or gases could create additional adverse effects.

#### (6) Archeological and Historic Values

##### (a) Salton Sea KGRA

There are no known archeological or historically important sites located within the project area. The sections involved in the proposed project possibly possess subsurface archeological features and associated cultural debris, but no surface materials were encountered during the 1973 archeological assessment. Should cultural materials exist, test drilling, production testing and development could have impacts. Construction of roads; movement and operation of drilling rigs, placement of containment ponds, and other features associated with test drilling and production testing could disturb archeological sites.

##### (b) Glamis KGRA

The eastern portion of Glamis KGRA, east of the Southern Pacific railroad track, contains numerous archeological sites. These early San Dieguito I sites, situated on extensive spans of desert pavement, are critical to the interpretation of early man in the Imperial Valley. Test drilling and production testing could destroy the integrity of those sites and erase significant scientific data on specific early hunting and gathering patterns in prehistory locally.

The central sector of the Glamis KGRA, composed of massive sand dunes and utilized principally as a recreation area for off-road vehicles and campers, contains several historical sites. This area south of Highway 78 was a major route for westward expansion in the mid-1800's. Wagons are frequently exposed via blow-outs in the low lying dune pockets. Archeological sites are also periodically exposed through the same process.

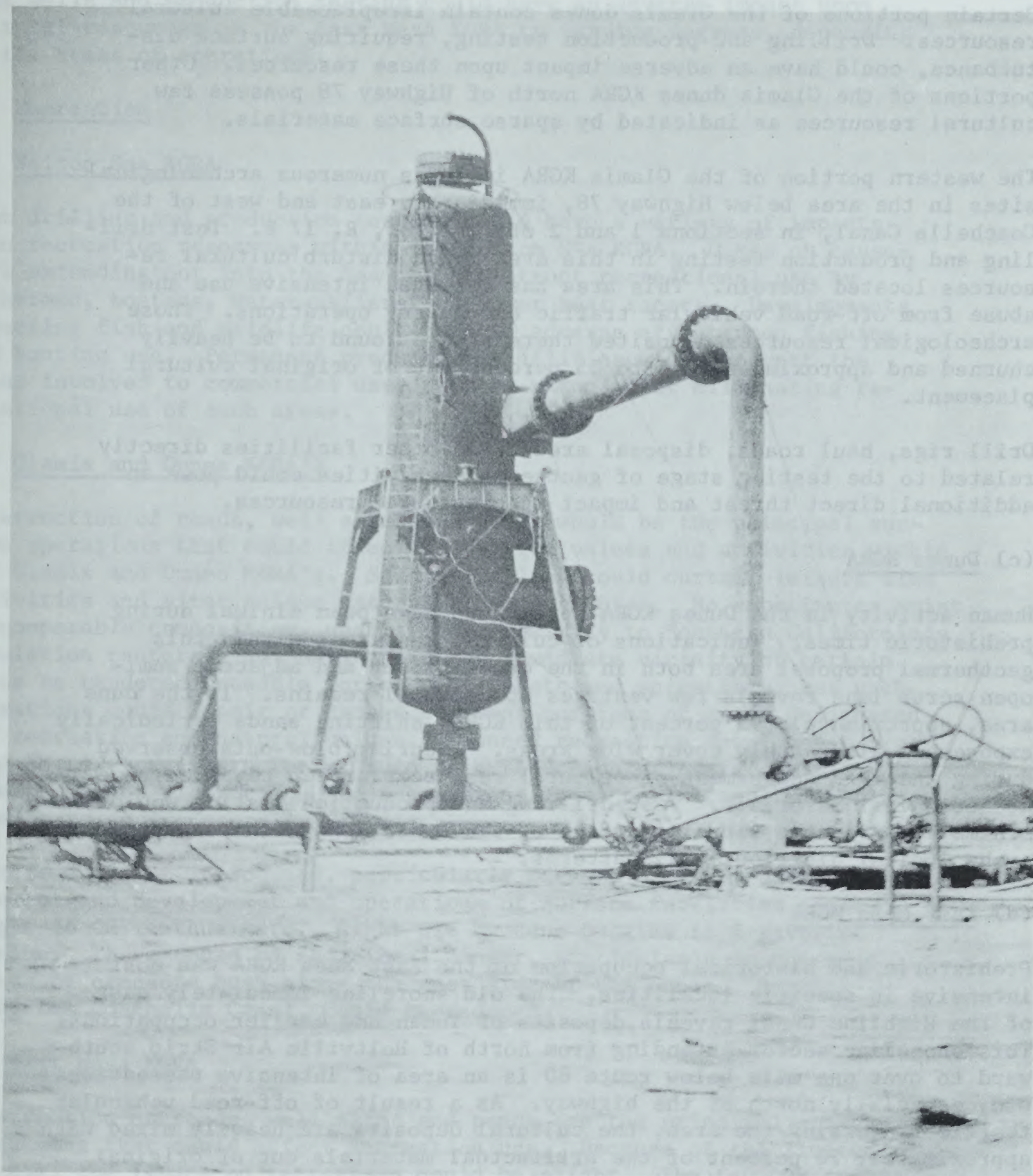


Photo I-14. Centrifugal water-steam separator employed at Cerro Prieto Hot-Water Geothermal Power development, Baja California, Mexico.

Certain portions of the Glamis dunes contain irreplaceable cultural resources. Drilling and production testing, requiring surface disturbance, could have an adverse impact upon these resources. Other portions of the Glamis dunes KGRA north of Highway 78 possess few cultural resources as indicated by sparse surface materials.

The western portion of the Glamis KGRA includes numerous archeological sites in the area below Highway 78, immediately east and west of the Coachella Canal, in sections 1 and 2 of T. 14 S., R. 17 E. Test drilling and production testing in this area could disturb cultural resources located therein. This area has received intensive use and abuse from off-road vehicular traffic and quarry operations. Those archeological resources deposited therein were found to be heavily churned and approximately 45 to 55 percent out of original cultural placement.

Drill rigs, haul roads, disposal areas, and other facilities directly related to the testing stage of geothermal activities could pose an additional direct threat and impact upon cultural resources.

#### (c) Dunes KGRA

Human activity in the Dunes KGRA appears to have been minimal during prehistoric times. Indications of cultural resources within this geothermal proposal area both in the dunes proper and adjacent semi-open scrub land reveals few vestiges of cultural remains. In the dune area, approximately 95 percent of this KGRA, shifting sands periodically expose and alternately cover wide areas. Occuring blow-outs observed during the 1973 assessment of cultural resources herein revealed some archeological materials. Test drilling and production testing would minimally alter the terrain surface of the Dunes KGRA with respect to archeological distributional patterns.

#### (d) East Mesa KGRA

Prehistoric and historical occupation of the East Mesa KGRA was most intensive in specific localities. The old shoreline immediately east of the Highline Canal reveals deposits of Yuman and earlier occupations. This shoreline sector extending from north of Holtville Air Strip southward to over one mile below route 80 is an area of intensive recreational use, especially north of the highway. As a result of off-road vehicular traffic traversing the area, the cultural deposits are heavily mixed with approximately 70 percent of the artifactual materials out of original cultural context. In addition to off-road vehicle usage, quarrying operations are intensive in five separate areas. Private citizens also utilize the lucustrine deposits here for a source of fill material. This action leaves cuts in the area exposing cultural materials.

East of the shoreline on the mesa proper, surface sites are abundant reaching eastward for over 2 1/2 miles in the southern sections. In the lower western portion of East Mesa KGRA archeological sites abound as in selected portions of the southern sector.

Test wells and production testing could have an adverse impact upon cultural resources in the East Mesa KGRA to varying degrees, depending on the areas of operations.

(7) Recreation

(a) Salton Sea KGRA

Test drilling and production testing could have a variety of impacts upon recreation resources within the Salton Sea KGRA. Dikes or causeways extending out into the Sea could obstruct recreational use by fisherman, boaters, water-skiers and power boat racers. Developments impacting fish and wildlife could have an adverse effect upon fishing and hunting use. Permanent production facilities would convert the areas involved to commercial use, thereby reducing or eliminating recreational use of such areas.

(b) Glamis and Dunes KGRA's

Construction of roads, well sites and ponds would be the principal surface operations that could affect recreation values and activities within the Glamis and Dunes KGRA's. Such operations could curtail leisure time activities and alter unique natural area attributes. No substitutes exist of comparable composition, quality and proximity to Southern California's population centers. Not only could the immediate vicinity of certain areas be rendered unusable for recreationists and scientists, but such operations could impair or damage adjacent portions of areas designated for recreation and natural values. Planned recreation development might have to be curtailed. There could be a reduction of overall visitor use or movement of visitor use to other areas which could result in adverse impacts to environmentally fragile areas.

Hazards could be introduced, particularly because of heavy equipment movement and development and operations of surface facilities posing danger to ORV enthusiasts. Night use by dune buggies is a favorite pastime. There could be additional danger, particularly in the huge stands of creosote bush along the west side of the dunes. Hunting along the Coachella Canal, could be reduced.

(c) East Mesa KGRA

Construction of roads, well sites and ponds are the principal surface operations that could affect recreation use. Because of the limited visitor use, the impact on recreation could be slight. The few ORV events, similar to those held in past years, could be held in other desert areas under the Bureau of Land Management's jurisdiction. Closing of the area to recreation use would affect few recreationists as most prefer more choice sites, such as the Dunes. BLM plans no recreational development in the area.

## (8) Mishaps

The principal unforeseeable environmental impacts which may be encountered in drilling and production testing in the Imperial Valley area are those resulting from uncontrolled flows of geothermal fluids. In any exploratory drilling in an untested area there is a hazard of such flows of steam, water, or gases, once drilling has been started. In extensive drilling in Imperial Valley, conducted over many years for petroleum and other resources, high-pressure zones have not been encountered and blow-outs have not been a problem. However, there were two uncontrolled flow incidents at Cerro Prieto, Mexico.

Other principal unforeseen impacts might occur through accidental release of saline brines, for example, failure of levees enclosing a brine storage pond or through pipeline leakage. These possibilities are continuing hazards, but can be minimized through proper planning, supervision, and maintenance.

Impaction of sand and gravel deposits may occur from any uncontrolled release of brine which results in the flooding of sand and gravel deposits. Such flooding could render the sand and gravel undesirable for construction purposes because of the added salt. Spills, seepage, or well blow-outs adding highly saline geothermal water to the Salton Sea could impair the fishery of the Sea.

Because of the high salt content of the geothermal fluid in the Imperial Valley, a well blow-out or another type of mishap could be detrimental to vegetation. The vegetation which comes in contact with saline water would be lost and the site possibly could be sterilized for several years due to slow leaching. The wildlife habitat provided by this vegetation could be lost.

The very rare spade footed toad found in the northeast portion of the Glamis KGRA inhabits sinks or depressions which collect water. A well blow-out or accidental spillage allowing saline fluids into these depressions could destroy the toads. Other wildlife could be harmed if impacted by saline fluid through some type of mishap.

Blowouts of wells could have a detrimental effect upon archeological deposits. Depending on the duration of flow, the flow could down-cut through cultural deposits. If the blow-out occurred in an area of loosely consolidated sands with cultural resources within, down-cutting could expose sections of sites or wash portions out of original context. Brines spilled by accident could create chemical reactions and build-up on lithic material which could dissolve or alter desert varnish in a short time. Ceramics could become encrusted with chemical build-up and accelerated disintegration.

c. Field Development, Powerplant and Powerline Construction, Energy Generation, and By-Product Facilities

(1) Water Resources

The environmental impacts of this phase on water resources are similar to those encountered in test drilling and production testing with regard to spills, aquifers, contamination and blowouts, in addition, major development will raise the possibility of land subsidence and/or increased seismic activity. These impacts would vary in proportion to the magnitude of development and the quantities of fluid extracted.

Power plants envisioned for the Imperial Valley are of the barometric condensor type, in which a supply of cool water is necessary to create a near-vacuum on the downstream side of the turbine. Experience at the Geysers has demonstrated that an external source of cold water is not required. The water that is discharged from the barometric condensers is cooled in wet cooling towers and recirculated back to the condensers. This method at the Geysers produce about 20% more condensate than that evaporated in the cooling towers. The supply of water for coolant also could come from a number of sources including the Colorado River, waste water from irrigation in the Imperial Valley, groundwater, or the Salton Sea.

The situation would be different for a binary system such as planned by San Diego Gas and Electric. Such a system requires an external source of water to condense the working fluid, for all the produced geothermal fluid is reinjected. Temperature of this cooling water (be it drainage water or water from the Salton Sea) would be unavoidably increased in the process, thus leading to increase evaporation when the heated cooling water is discharged to the Salton Sea. The net result could be a lowering of the level of the Salton Sea and an increase in salinity.

At the present time, there is concern about the gradual rise of the water level and increase of salt concentration in the Sea. Removal of water from the sea for use in cooling might be acceptable; however, disposal of that water after use in the cooling system by returning it to the Sea at a reduced volume, but increased concentration of salts, could add to the increasing salinity pollution. The magnitude of the impact would depend upon the number and size of such installations. Similar problems could result from the use of wastewater from the irrigation system or the use of water from the Colorado River.

Ground water is an alternative supply of water for cooling towers. Use of ground water for this purpose could carry with it the same basic series of problems regarding the effects of spills, of subsidence, and waste disposal that are encountered with the geothermal fluids, except that the problems of corrosion, scaling and high temperature fluids may be lessened.

Disposal of wastes from the cooling towers by injection, regardless of the source of the water, includes many of the same problems that will be encountered in reinjection of geothermal wastewater.

## (2) Air

### (a) Noise

During field development, there will be some noise associated with well drilling, but as described earlier, this is of relatively low level and short duration. Wells are capped after initial testing so noise from this source should be isolated and, with the use of mufflers, of a low intensity level. The construction of power plants and by-product facilities will emit noise associated with building activity until the facilities are completed. Some noise may be produced by the operation of cooling towers but this will be noticeable only in the immediate vicinity of the towers.

The potential for loud noise exists if steam lines or wells should break. However, this would be of short duration until repairs could be effected. During full production considerable noise may be emitted whenever expanding steam is released. For example, at discharge lines where waste water issues from steam-water separators, the residual steam contained in the waste fluid escapes with a loud rumble.

The noise pollution level from the steam separators, power plant and by-product facilities could probably be tolerated by the off-road vehicle enthusiast, since his motorized vehicle, during operation, probably produces noise levels in excess of those produced by the well complex. However, the noise produced from the Geothermal complex would be constant and continued around the clock, which could adversely impact the camping recreationist.

Refer to Volume I, Chapter III for a more complete description of noise pollution.

### (b) Gaseous Emissions

Non-condensable gases including carbon dioxide, hydrogen sulfide, oxygen, and trace amounts of hydrocarbons normally are extracted from the steam after it passes through the turbine and are then ejected to the atmosphere. The bulk of the non-condensable gas is carbon dioxide, but hydrogen sulfide can be expected in most geothermal waters in sufficient quantity to pose unpleasant odors or problems of compliance with air-quality regulations. Water vapor will be vented from the cooling towers, but the water itself is not expected to be of significant concern in the dry atmosphere of Imperial Valley. The condensed steam, however, may contain contaminants, which if present in high concentration, could prove damaging to plant

and animal life depending upon mode of release. Vegetation exposed to air pollutants could be adversely affected. Both aquatic and terrestrial animals could be adversely affected from ingestion of natural foods damaged or contaminated with emission fallout. Existing geothermal experience indicated, however, that biotic problems of this type generally would be negligible.

If the gaseous emission levels were comparable to those of the Cerro Prieto wells in Mexico, emissions from the production of geothermal steam could be incompatible with recreation use due to the nauseating odor and toxicity of the gases.

Refer to Volume I, Chapter III for a more complete description of gaseous emissions.

### (3) Land Use

In the Imperial Valley area, the increased impact from full-scale development would result from drilling of numerous wells, construction of pipelines from the wells to points of use, construction of power plants and transmission lines, facilities for reinjection of spent brine, and possibly from by-product plants.

The engineering problem of heat loss from the fluid in transit would be similar to that of The Geysers field, which requires small power plants close to the wells with insulated surface piping. The geothermal development at Cerro Prieto, Mexico, which is a hot water system, can serve as a model of the type of power plant development to be expected in the Imperial Valley area. (Photo I-15) At Cerro Prieto, some 15 producing wells, distributed over an area of about 1 square mile, supply steam to a 75 MW plant at a maximum distance of 1 mile. It is estimated that each power plant and associated producing wells would not use in excess of 800 acres of land. The fluid produced by the wells there consists of about 25 percent steam and 75 percent water. A centrifugal-type separator at each well separates the fluid, and the steam is conducted to the power plant in 12 34-inch insulated, above-ground, pipelines. The operation is similar in scale and methodology to any one of the plants at The Geysers field except for the feature of water separation. At Cerro Prieto, the waste water is disposed of by surface discharge.

Assuming a similar pattern of development to that of Cerro Prieto, one could expect development of several centers of power generation, each with a power plant and network of radiating pipelines to wells. In addition, a pipeline system would be required to collect waste water from the producing wells and to convey it to reinjection wells located strategically throughout the field. Such surface modifications would represent a decided change in land use, but not necessarily a severe environmental impact.

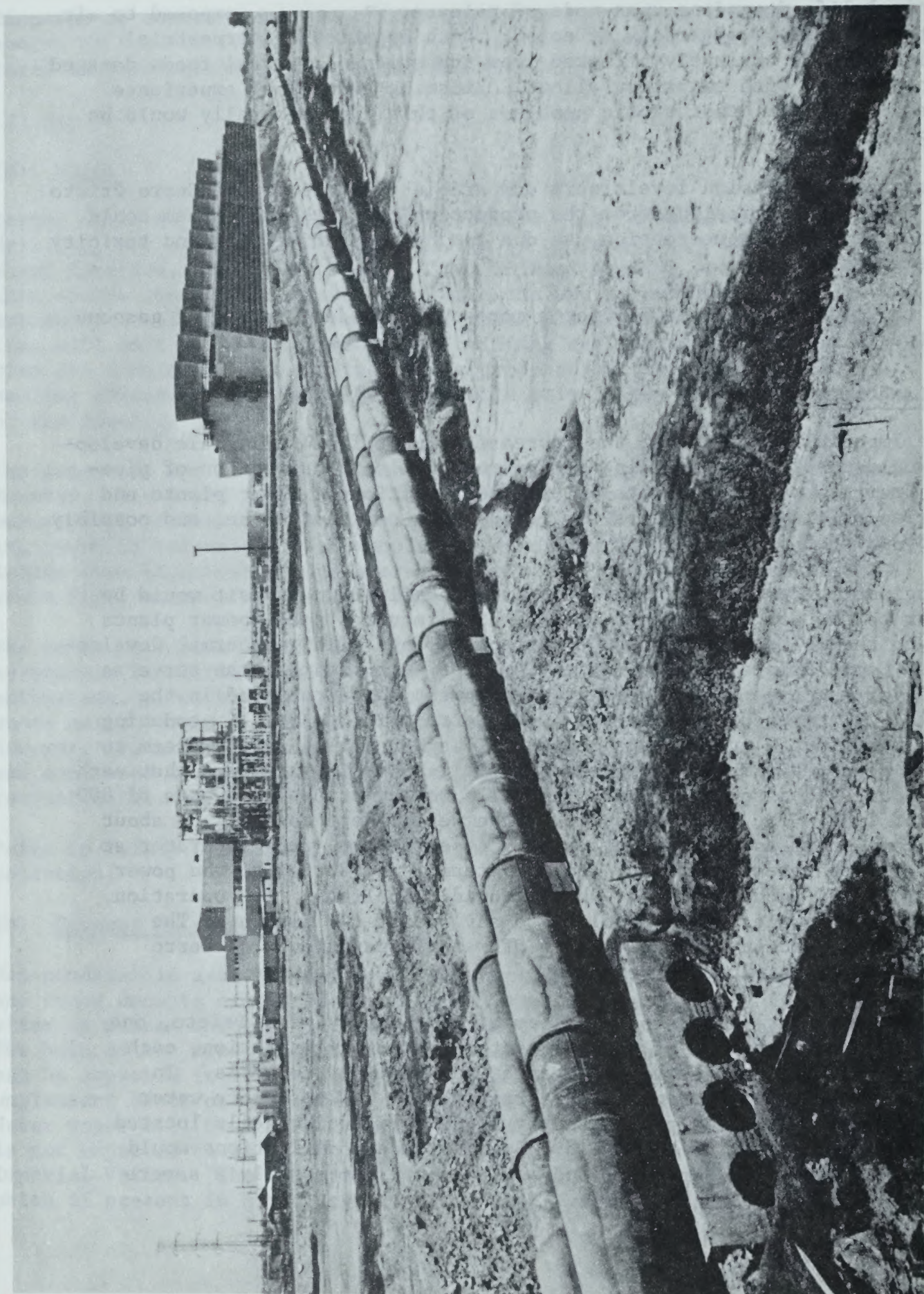


Photo I-15. Cerro Prieto, Mexico. 75 Megawatt power plant (left) and cooling towers (right). Steam lines from wells in foreground.

#### (4) Land Subsidence and Induced Seismic Activity

The principal environmental impacts which may occur in the Imperial Valley area are land subsidence and the possibility of inducing seismic activity. One of the potential hazards of ground-water development in Imperial Valley, either for geothermal power or for water supply, is the threat of land subsidence. Whenever fluids are extracted from a ground-water reservoir--that is, withdrawals exceed the recharge and the reservoir pressures continue to decline--land subsidence may occur. Throughout much of the developed area of the Imperial Valley, subsidence could cause costly damages, mainly through change of grade of irrigation canals and drain ditches, and through change of slope of farm lands and underground tile drains, both of which are laid to specific grades. In outlying developed areas subsidence might be tolerated. In either setting, the likelihood of subsidence resulting from the extraction of reservoir fluids must be fully considered. The hydrogeologic parameters affecting the magnitude, extent, and rate of subsidence should be understood. Subsidence results from the compaction of compressible beds of the aquifer system as effective stresses are increased by fluid-pressure reduction. The magnitude of this subsidence is dependent on the effective stress increase caused by the pressure drop, the compressibility of the deposits, the thickness of the compressible beds, the time the increased stress has been applied and also on the past stress history--whether the increased stress is being applied for the first time or has been attained or exceeded previously. Although a small part of the subsidence may be elastic in nature and tend to rebound when the stress is removed, most of the change is nonelastic and nonrecoverable.

Land subsidence caused by the exploitation of oil and gas resources and intensive pumping of ground water is relatively common throughout the world. Recently subsidence has been related to the extraction of geothermal waters at Wairakei, New Zealand, and Cerro Prieto, Mexico. Although the geologic setting of these locations differs considerably, the basic cause of subsidence is the same--the reduction of fluid pressure causing a marked increase in effective stress. At Wairakei, J. W. Hatton, (Ministry of Womes, Wairakei, New Zealand) in an unpublished paper, reports maximum subsidence of 1.3 feet in 1967, with the subsidence centered 1,500 feet east of the main borefield, and extrapolates the rate of 1.3 feet/year to suggest that "the total subsidence to date (1969) exceeds 10 feet at this point." Hunt (1970a, 1970b), on the other hand, presents data showing subsidence of up to 2.3 feet from August 1961 to May 1968, with the maximum subsidence centered on the main production borefield and subsidence extending over about 25 mi<sup>2</sup>. The discrepancies between Hatton's conclusions and Hunt's conclusions cannot be resolved with the data at hand.

Differential subsidence of the magnitude suggested by either data set, however, would cause serious problems in the irrigated area of the Imperial Valley, where irrigation canals and drains have slopes on the order of 5 feet per mile or less.

At Cerro Prieto, subsidence has been measured 7 miles outside the well field even before the beginning of extensive production. It is reported that the subsidence there is as much as 7 inches to date. Corresponding effects could be expected to occur in Imperial Valley unless provisions are made to maintain reservoir pressures. As in oil-field or artesian ground-water production a direct relation exists between subsidence and fluid-pressure decline in a geothermal field. Subsidence can be minimized or prevented by maintaining fluid pressures by either natural or artificial recharge.

Most of the parameters for predicting subsidence in Imperial Valley, such as anticipated pressure decline, thickness and compressibility of the water-bearing deposits, and lateral extent of fault blocks are not well known. Subsidence probably will occur if geothermal waters are extracted for an extended period. Both fluid pressures and surface benchmarks will need to be carefully monitored to determine production effects. Also, because Imperial Valley is tectonically active and reportedly is subsiding naturally at a rate of about 1 foot per century, provisions should be made in a monitoring program to differentiate tectonic subsidence and that caused by geothermal development.

Another potential environmental impact that requires consideration in the Imperial Valley area is increased seismicity induced by geothermal development. Imperial Valley is traversed by several major active faults and is known to be one of the most seismically active areas in North America. Earthquakes are commonplace events, and major earthquakes of Richter scale magnitude of 7 or greater occur every few years.

Experience in other areas indicates that increased seismic activity, in the form of swarms of micro-earthquakes, has occurred as a result of fluid injection into confined systems. Similarly, heavy production of fluids from confined systems, which causes land subsidence, has also been related to tectonic activity, such as displacement on fault surfaces as the confined system readjusts to changing stress.

A potentially serious impact associated with the field development stage involves the risk of triggering a damaging earthquake by changing the pore pressure in an active fault zone due to injection or withdrawal of large volumes of fluid. Earthquakes have been clearly linked to the injection of fluid in wells at the Rocky Mountain Arsenal near Denver, Colorado, and the Rangely oil field in northwestern Colorado (Raleigh, 1972). In both cases evidence suggests that the reservoir rocks were

under substantial tectonic shear stress--a situation that exists in each of the KGRA's in the Imperial Valley. In the Denver series, earthquakes with magnitudes up to 5-1/2 were triggered at distances of several km from the base of the injection well (Healy, et. al., 1968). Earthquakes have also been triggered by the withdrawal of large volumes of fluid. In the case of the Wilmington oil field near Long Beach, California, the earthquakes were apparently associated with large scale subsidence (Kovach and Archambeau, 1972).

It is difficult to assess the extent of this hazard in the KGRA's of the Imperial Valley. Massive reinjection, as would be necessary for full development of the geothermal resources of the Imperial Valley, has never been attempted, especially in an area of known high seismic activity. If one could guarantee that the fluid produced would be returned to its source volume, one could reasonably infer a low probability of triggering earthquakes. But reinjection unavoidably will be away from the exact production area, and accordingly there will be a finite but uncertain probability of increasing the pore fluid pressure of rocks already under stress which could be conducive to triggering a potentially damaging earthquake.

It is not felt that microearthquakes related to subsidence are likely to be significant in the development of the geothermal fields in the Imperial Valley. Significant subsidence could be costly or even intolerable in the Imperial Valley from a point of view of land configuration.

(5) Vegetation

(a) Salton Sea KGRA

Construction of power and by-product facilities and development of a geothermal field could destroy vegetation. Revegetation of these areas would be difficult because of desert conditions. Native species may, over time, become reestablished in some areas.

Condensed steam from power plants may contain contaminants, which if present in high concentration, could prove damaging to plants by affecting the plants ability to store food in their roots for growth of green leaves. Development to date, in the case of The Geysers, has not resulted in visible adverse effects.

If the Sea's salinity increases, vegetation in marsh areas would begin to change. Quantities of vegetation would decrease and the less tolerant species would be stressed and perhaps become incapable of maintaining their niche in the ecosystem.

(b) Glamis KGRA

The development of the geothermal fields within this KGRA could have a major impact upon vegetation. The bajada and creosote aspects will be altered, and much of the perennial vegetation would be disturbed or destroyed in the areas developed. It is estimated that full development of a geothermal field in the Glamis vicinity could damage or destroy more than one-half of the vegetation in Creosote Forest and the Bajada Mixed Communities, of the areas involved as entities will be altered, possibly beyond restoration.

Access roads, well sites, powerline rights-of-way and maintenance roads, generating plants, cooling towers, operation facilities, and brine ponds could be established possibly with a frequency of one complete complex per square mile. This type of development within the small bajada and creosote communities could eliminate them as significant botanical areas. The perennial plants could be replaced by lesser plants, such as annuals, in the plant succession. The vegetative community associated with the active dunes will be less compromised in that perennial plants are very sparsely scattered and the area presently offers a very barren aspect.

(c) Dunes KGRA

The Dunes KGRA offers a barren aspect, even within the sparse creosote community. Full development of this field would not be expected to impact the communities beyond repair. During the actual development process much of the area would be disturbed and considerable amount of the existing perennial vegetation could be removed. However, after the field is developed and producing, reestablishment of the native species could be expected, though the process would take a 5 to 15 year period.

(d) East Mesa KGRA

Total development of the geothermal field within the KGRA could have varying impacts on the two major plant communities. The Dunes community with its vegetation and low growth forms, would not be impacted as much as the well developed Creosote community near the south end of the KGRA. The basic barrier aspect of the Dunes area, would not be lost upon development of the field, and once the production stage of the proposal had been reached slow reestablishment of vegetation could be expected.

The Creosote community, upon full development of the geothermal field, could lose much of its continuity as a uniform type. However, this area has been disturbed in several locations during previous years, and is not considered a pristine community. There are no specific botanical losses identified in association with geothermal development within the community.

(6) Fish and Wildlife

(a) Salton Sea KGRA

The field development, powerplant and powerline construction, energy generation, and by-product facilities of geothermal resources in the Salton Sea KGRA could have varied impacts upon fish and wildlife resources and habitat.

The major potential impact upon fish and wildlife habitat with complete development, as with test drilling and production testing, could result if geothermal brines were introduced into the Salton Sea. Physiological stresses placed on organisms within the fishery food chain and fish reproduction could adversely affect the fishery. If saline waters reach the adjacent ponds or tributary drainages fishery resources could be adversely affected. Significant modification of the acreage or character of Federal or State game management areas through addition of saline water could be destructive. Loss of waterfowl feeding and nesting areas could occur.

If pollutants such as boron, arsenic, fluoride, or zinc are released into the water system, birds and fish populations could become endangered.

Release of heated effluents into waters of the area could alter aquatic habitat and life, perhaps creating temperatures intolerable to fish. The increased water temperature could facilitate growth of toxic and nuisance-causing algae and disease producing organisms.

Facilities needed for development (islands for a pump platform, supports for pipelines, roads, transmission lines, and by-product facilities, etc.,) could result in additional loss or modification of wildlife habitat.

Surface powerlines could present a hazard to birds which might hit the lines or towers in flight or be electrocuted. Powerlines placed in bird flyways or over resting and feeding sites could be the most hazardous to birds. Some of the waterfowl moving between fields and water, probably would hit powerlines. The magnitude of potential loss is difficult to forecast.

Where existing public access would be restricted in order to reduce hazards to the public, there could be an accompanying reduction in fishing and hunting opportunities. The importance of these losses would depend upon the present intensity of use and the capacity of other available habitat areas to absorb the pressures which are presently absorbed by the geothermal area.

(b) Glamis KGRA

If the Glamis geothermal field were to be fully developed for production of power, certain habitat types would be drastically altered and possibly destroyed. The bajada and Creosote forest communities would be most effected. These areas would continue to support a variety of wildlife species after development, however the integrity of the existing biological complex would be lost. It is possible that such species as the spade foot toad, the diamondback rattlesnake and possibly the desert tortoise would be reduced, or even disappear, from the area. The potential for destruction of crucial habitat areas would increase, and the possibility of disturbing or eliminating den sites and sink areas could be great.

Under full development, the small seep areas along the Coachalla Canal could be damaged or destroyed. Contamination or physical alteration of the associated habitats could reduce or eliminate wildlife use of these areas. Permanent facilities adjacent to these sites, could have a detrimental effect on those species of wildlife that are intolerant of human activity. Use of these sites and adjacent habitat by animals can be expected to decrease upon development. Hazards to large perching birds from associated powerlines would increase as well as losses incurred by birds flying into newly established lines. Migratory birds are most vulnerable to the addition of highstructures, in that migration flights are instinctive and new structures often are not detected on night flights.

(c) Dunes KGRA

Though the wildlife resources of the Dunes KGRA appears to be of minor significance, it must be understood that the data available is by no means conclusive. The development of the associated geothermal field would have impacts on the local biological complex. What these impacts

entail and what will be lost or impacted may become more clear as development approaches. To date, there has been no significant species specifically tied to the area. Those rare or threatened species identified with the Dunes KGRA may or may not be effected. At this point, it is anticipated that full development of the geothermal resource in this area will not effect the status of any of the wildlife species currently inhabiting the area. However, further studies and inventories may identify potential impacts.

(d) East Mesa KGRA

Development of the geothermal field in this area could have impacts upon the existing biological complex. Some species may abandon the area upon permanent occupancy by humans. The species that might be involved cannot be predicted at this time. Local areas occupied by geothermal plant facilities and associated activities will occupy portions of the existing habitat, and those areas will be lost in part or totally for the duration of occupancy. Rehabilitation will occur on these sites after abandonment. This process as it occurs naturally is extremely slow, especially in areas of extreme disturbance.

There have been no specific sites associated with rare or threatened species identified within this area, however it is known that the desert tortoise, diamondback rattlesnake, and several species of rare lizards do inhabit this KGRA. The effects of development of the area on these species cannot be predicated at this time. It must be understood that these biological communities are among the least understood complexes in North America.

(7) Aesthetics

(a) Salton Sea KGRA

The impacts on aesthetics in the Salton Sea KGRA from full development would be similar to the impacts from testing and production testing, except they would be of a larger magnitude. Full development is more extensive and involves larger facilities that may operate for from 25 to 50 years at each location.

(b) Glamis and Dunes KGRA's

Visual, audio and olfactory effects could be significant. Construction and continuing daily operations could be detrimental to public use attracted by unusual natural assets of the KGRA. Man-made industrial structures would be introduced in a desolate, almost pristine, desert setting that is geomorphically and ecologically unique. Scenic qualities, which contribute to a current 1,500,000 visitor-use-days a year, would be reduced.

On lands undisturbed by development, construction and operational noise could extend over broad acreages used by the public for recreational purposes. Mishaps such as ruptured steamlines or well blow-outs also could be a source disturbance to recreationists.

Gaseous emissions, such as  $H_2S$ , could be objectionable to public users. Destruction of vegetation and wildlife mortality would also reduce aesthetic qualities of the landscape. Settlement ponds, steam blow-off, interconnecting steam, pipelines, towers, buildings, powerlines and associated structures would be incompatible with the existing aesthetic quality and could impair enjoyment by recreation users.

(c) East Mesa KGRA

Few recreationists enter the East Mesa area in comparison with Imperial Sand Dunes. Motorists using Interstate 8 would see an industrial project where previously was a desert vista. Because of flat topography and sparse vegetation the power plant, powerlines, steamlines and by-product facilities could be seen from considerable distances, especially from this high ground surrounding the valley.

Noise and gaseous emissions could have some adverse impact on travelers along the highway.

(8) Archeological and Historical Values

Full development of geothermal production sites, including construction and operation of power plant structures, powerline construction, energy generation and by-product productions, could have similar impacts in all four KGRA's. Disturbance of any nature to cultural resources either during reconnaissance, test drilling and production, or full development of geothermal facilities has essentially the same effect on archeological materials and historic features. The intensity of development relative to the location of archeological and historic values will determine the degree of impact which may range from little or no significance to total destruction of such values.

(9) Recreation

(a) Salton Sea KGRA

The impacts of full development on recreation in the Salton Sea KGRA would be similar to the impacts from test drilling and production testing. They would be greater in the sense that development is on a more intensive and permanent scale. Restriction or reduction of areas available for water-based recreation such as boating, water skiing, fishing, etc. would have the greatest public use impact.

(b) Glamis and Dunes KGRA's

Full scale development, with its attendant drilling of wells, construction of pipelines from wells to points of use, power plants, transmission lines, by-product extraction plant, roads, and facilities for storage and reinjection of spent brines, etc. could adversely affect recreation values and impair public use in the dunes. The geothermal complex in Cerro Prieto, Mexico, has 15 producing wells and covers an area of one-half a square mile in the immediate vicinity of the plant. Depending upon their location, similar installations in these KGRA's would exclude public use from large areas.

The surface modifications could be incompatible with existing recreation and natural area uses and values. There also could be a reduction in the qualitative character of the adjacent undeveloped acreage that would be left open to recreational use.

Potential hazards to users would increase, especially to off-road vehicle users and to sightseers. Hunting along the Choachella Canal might be curtailed. Development and use plans for the recreation lands would have to be modified. A National Natural Landmark and a proposed natural area would be disturbed. Some local economic losses could result because of reduced recreation expenditures. Large numbers of recreationists from Southern California metropolitan areas could be deprived of a unique recreational location that has become a traditional use area. If they were to seek out other areas for similar activities, particularly off-road recreational uses, significant adverse environmental impacts to the fragile desert environment could result if such uses were incompatible with the environmental setting.

(c) East Mesa KGRA

The recreation values and actual use of East Mesa are minimal. Few recreationists would be affected. Motorists along I-8 might find industrialization objectionable in any portion of the desert. Geothermal facilities could present a safety hazard to recreationists who might enter the development area.

## (10) Minerals

The placement of a geothermal well and plant complex on sand and gravel deposits could impact these resources by physically restricting or prohibiting mining operations.

## (11) Social Effects

The social effects of development, construction, energy generations, and by-product facilities are similar for all four KGRA's in the Imperial Valley.

## (12) Economic

The development of geothermal power-generating facilities can be expected to contribute tax revenue to both State and county governments. County tax revenue per unit of power generating capacity could be similar to Sonoma County revenue from the Geysers, assuming equivalent tax rates, since well and plant costs should be similar. Sonoma County annual tax revenues currently are approximately \$2500 per megawatt of plant capacity. Assuming each plant at 100 MW, yearly revenue per plant would be \$250,000. In addition to mineral and property tax, both the State and/or county could benefit from sales, income and other taxes.

Government royalty income could be significant. Assuming a slightly higher sales value to the producer than at the Geysers for the hot water or steam used to generate electricity, in order to compensate for higher waste water injection costs, yearly gross income per 100 MW plant to the producer could be on the order of \$3 million. At a Government royalty rate of 10 percent the annual royalty income would be in the range of \$300,000.

By-product revenue and royalty are subject to much more uncertainty than electrical power generation, but could be significant for the mineral-rich Salton Sea KGRA geothermal fluids.

Local spending by drilling crews and construction workers could have minor to significant effects on the local economies, depending on the amount of geothermal development and size of the nearby communities. As currently envisioned, development would take place over a period years. Experience has shown that increases or decreases of a moderate (3-6) number of rigs operating can have a significant effect on nearby small towns.

Permanent employment (plants, generating facilities, production and well maintenance crews) would not be expected to be large; however, their impact may be minor to significant, depending upon local economic conditions.

### (13) Population Distribution

No significant permanent change in population size or distribution is expected as a result of geothermal developments in the area. Drilling crews and construction workers generally are transient and temporary housing is available for this small number of employees involved. Power-generating facilities and by-product recovery plants will require only a limited number of employees who can readily be accommodated within existing communities.

### (14) Transportation

Only minimal increased traffic can be expected as a result of geothermal-related activities in the Imperial Valley area. By-product shipment to various market areas probably would be by rail so some increase in rail traffic may result. An increase in truck traffic would occur in the immediate areas of development.

### (15) By-product Industries

Geothermal development may support in addition to power generation, industry related by-products recovered from the hot saline brines. Past pilot-plant testing of a mineral recovery facility did not prove economically feasible, but a change in the market situation or improvements in technology may alter this situation in the future. There is a possibility of recovering fresh water along with other by-products in the brine, but this development also awaits verification of feasible economic methodology. (U.S. Bureau of Reclamation, 1972; Univ. of California, Riverside, 1972; and, U.S. Department of the Interior, 1972).

### (16) Mishaps

The potential for impact of blowouts and accidental spills of geothermal brines is discussed earlier in this chapter under test drilling and production testing.

#### D. MITIGATING MEASURES INCLUDED IN THE PROPOSED ACTION

Mitigation of potential adverse environmental impacts of development of Federal geothermal resources in the Imperial Valley Area can be accomplished through enforcement of applicable Federal and State laws and regulations, geothermal leasing and operating regulations, GRO Orders, and lease and land-use permit stipulations. Local ordinances as appropriate will be implemented through GRO Orders. The general provisions of the foregoing laws and regulations are described in detail in Volume I, Chapter III, Section C of the general statement; therefore, this section will be limited primarily to mitigating measures specific to the areas considered in this section.

Monitoring will be conducted for potential impacts in the Imperial Valley related to exploration, development, and production of geothermal resources. Such impacts include, but are not limited to, noise, air quality, water quality, radioactivity, erosion, fish and wildlife, seismicity, and land subsidence. Monitoring may take the form of continuous recording of parameters, periodic sampling, or areal survey at intervals.

The extent and frequency of required monitoring activities will differ from place to place owing to natural variability of geology, terrain, biological factors, climate, etc. Therefore, technically appropriate measures to monitor environmental impacts will be determined on a case-by-case basis after the decision has been taken to consider lease sales in a given area. In any event, it is essential that appropriate monitoring activities be instituted prior to development so that potential impacts can be subjected to an adequate before and after assessment.

Monitoring of short-term localized impacts such as effluent discharges, noise and air quality, which are readily identified and associated with specific activity on an individual lease, will be the responsibility of the lessee, under the supervision of the U.S. Geological Survey, and will be required as a stipulation in the lease or through GRO Orders.

However, water quality as related to an entire drainage area normally would be the responsibility of the appropriate public agencies. Land subsidence and seismic monitoring pertaining to general development throughout the producing area and would be a governmental responsibility with detailed work on individual leases carried out by the lessee. Currently, considerable monitoring is under way.

The Imperial County geothermal ordinance adopted in May 1971 presents terms, conditions, and standards for geothermal development on private lands, which among other things requires noise monitoring by the operators to assure compliance with recommended standards of the USA Standards Institute. In the area of water quality, the Regional Water Quality Control Board requires monitoring by operators of the amount and quality of geothermal fluid produced and the disposal of these fluids as a stipulation in waste discharge orders insured for each separate operation. In addition, the quantity and quality of water in the Alamo

and New Rivers and in major drains discharging to the Salton Sea as well as the Salton Sea itself is monitored extensively under the State's surface water-quality monitoring program.

Monitoring of land surface movement was begun in 1972 as a cooperative venture among the State of California, Imperial County, NOAA, Bureau of Reclamation, U.S. Geological Survey, and private industry under the direction of the California Division of Oil and Gas. Monitoring of seismic activity is being conducted by the U.S. Geological Survey using a net of 16 seismographs with data telemetered to the California Institute of Technology.

Mitigating measures for any subsidence or increased seismic activity that can be attributed to geothermal development and production could include actions such as altering rates of production or injection, changing points of injection, or stopping production.

Control of unforeseeable mishaps is not subject to rigid regulations, but the Departmental Operating Regulations provide authority for the Supervisor to act promptly to effect control over immediate problems such as blowouts and fires. To date no major mishaps, such as blowouts, have occurred during geothermal operations in Imperial Valley. However, two uncontrolled flows of fluids have occurred in the Cerro Prieto development in nearby Mexico (described in the general statement, p. III-9).

The proposed operating regulations for drilling on Federal leases provide safeguards for control of accidental flows, in the form of strict casing and completion requirements and installation of blowout preventers.

Specific aspects of monitoring are described in the following sections. As previously indicated, generally monitoring of processes that cannot be readily associated with activity on an individual lease, such as changes in water quality, (including sediment yield) fish and wildlife values or processes that are of regional scope, such as land subsidence and seismicity, will be the responsibility of public agencies.

#### 1. Water Resources

The principal mitigating measures to avoid adverse environmental impacts on water resources in Imperial Valley are measures designed to prevent water pollution in the form of degradation of water quality in surface channels or in the aquifer system, to avoid the occurrence of land subsidence, and to minimize stimulation of additional seismic activity.

Water pollution is controlled under Federal, State, and county regulations that specify standards and permissible operating procedures and practices. Compliance should make it possible to prevent significant water pollution in the area.

Water pumped from a confined reservoir not recharged at the same rate by natural or artificial recharge is mined from the formation and can cause subsidence. Experience in many areas of intensive pumping, particularly in the San Joaquin (Lofgren and Klausing, 1969; Poland and Davis, 1969) and Santa Clara (Poland, 1969) Valleys of California, indicates that ground water cannot be mined from unconsolidated or semiconsolidated deposits without causing land subsidence. Particularly in the confined aquifer systems a direct relation exists between pumpage and land subsidence.

Reinjection of wastewater is a means of mitigating the effects of fluid pressure reduction due to extraction of geothermal fluids. If reinjection is done in the same depth zone as extraction, and in sufficiently close proximity to the extracting wells, reinjected fluids can be used to maintain the formation fluid pressure in the geothermal aquifer system. Selection of positions of reinjection wells will be somewhat experimental, based on the geology of the materials underlying the site selected as inferred from in-hole geophysical logs, and on the results obtained from surface monitoring of land subsidence, seismic activities and monitoring bottom hole pressures in wells as development proceeds.

Water pollution control under the Federal Water Pollution Control Act is primarily a State responsibility, and in California is vested in the State Water Resources Control Board. Enforcement of State-Federal regulations is carried out by nine regional water quality control boards. The Imperial Valley is in the area of jurisdiction of the Colorado River Basin Regional Water Quality Control Board. Water-Pollution control is exercised by the regional boards by the procedure of waste-discharge orders issued for specific waste-discharge situations.

Basically, the objective of water-quality control as applied to Imperial Valley and the Salton Sea is to protect the shallow ground waters and Salton Sea from further degradation. With respect to geothermal development, this is regulated by prohibiting discharge of waste fluids of poorer quality than present inflow to Salton Sea from the New and Alamo Rivers. Specifically, discharge of wastes to shallow ground waters or surface waters whose total concentration averages greater than 4000 mg/l or exceeds 4500 mg/l is prohibited. It is further specified that this prohibition may not be bypassed by diluting the wastes. The comparable temperature requirement prohibits raising river temperature more than 2° F.

The practical effect of these regulations is to require reinjection of geothermal wastes into subsurface reservoirs from which the water cannot escape to the surface environment, for example, reinjection to the producing zone would be acceptable. Evaporation of geothermal fluids is another acceptable alternative; however, in such cases, any solid waste remaining must be removed from holding basins and discharged at a solid waste disposal site approved by the Regional Water Quality Control Board to receive such type of material. Under Section 3204.1(c)(2) of the

leasing regulations and Section 270.41 of the operating regulations, compliance with such State orders will be required of lessees of Federal land.

The present prospects for geothermal development entail disposal of waste by reinjection to the producing zone or by evaporation from surface ponds. Experimental reinjection of brines into the producing zone in the Niland area has shown promising results. During a 1-year test, brine produced from a well 3,100 feet deep at a rate of about 640,000 gallons per day was used in a pilot plant, and the residual saline water was reinjected into a nearby well 6118 feet deep. Except for initially overcoming a well-head pressure of about 200 psi, flow into the reinjection well was under gravity. During the year 190 million gallons of brine was produced, of which 126 million gallons was reinjected, the difference representing evaporation. Attempts of reinjection into a shallow zone of a depth of about 1500 feet resulted in plugging of the injection well in a very short time.

Evaporation from surface ponds is feasible for disposing of limited volumes of waste water produced during short tests, but would not be feasible for disposing of waste water under full-scale production because of the land requirement. For example, to evaporate 126 million gallons of fresh water at an evaporation rate of 6 feet per year would require a 65-acre pond. Evaporation of highly concentrated brines would require an even greater acreage.

Waste liquids from by-product plants will also be reinjected into the producing formations rather than discharged to surface drains. Care must be exercised in combining various waste products as resultant chemical reactions may lead to the reduction of pore spaces surrounding the injection well and reduction of intake capacity.

Well drilling and completion practices that include casing fitted with centralizers at appropriate intervals (50-150 ft.) with cement filling in each annular space should insure against subsurface corrosion by geothermal brines for many years. If a decision is made to abandon a test well, it must be filled with cement to a sufficient depth to prevent upward movement of brines to overlying ground-water bodies. An example of a well designed cement program has been prepared by the U.S. Bureau of Reclamation.

In addition to the State requirements, Section 3204.1(c)(2) of the leasing regulations prohibits release of toxic materials to surface, or underground waters except for reinjection operations with approval of the supervisor. Furthermore, Section 270.41 of operating regulations prohibits pollution of surface and underground water, and requires approval by the supervisor of plans for disposal of well effluents before action is taken under them. With respect to Federal leases in the Imperial Valley area, it is expected that the presently accepted practice of returning waste fluids to the producing reservoir will be followed by Federal lessees.

It should be noted that Regional Water Quality Control Board Waste Discharge Orders require the operator to monitor quantity and quality of fluids produced and disposed of and monthly reporting of such data to the regional board. They further specify means of disposal of drilling wastes, and have specific requirements for construction and maintenance of fluid storage basins to prevent seepage and to assure against failure of protective dikes.

In addition to monitoring specifically related to geothermal production, State and Federal agencies maintain regular water-quality monitoring stations at 17 sites on canals in the Imperial Valley area.

## 2. Air Resources

Provisions for the prevention of air pollution and protection of employee health and safety from airborne substances, as described in the general statement, are found in Federal and State of California Regulations. Emissions from motor vehicles are regulated by the State Motor Vehicle Pollution Control Standards and are applicable to vehicles used in geothermal activities.

California Ambient Air Quality Standards establish, among others, limits on particulate, carbon monoxide, and hydrogen sulfide emissions, which apply to potential geothermal developments on Federal lands in the Imperial Valley area. Jurisdiction over and control of sources of air pollution are vested with the appropriate county air pollution agency. Failure of a county agency to control pollution according to the State plan for achieving air-quality standards can result in the State assuming authority to abate air pollution.

Ambient air-quality standards have not been established for other gases and vapors which may be emitted from wells in the Imperial Valley area. Because of local temperature inversions, release of gases and vapors which are normally below health and safety standards could lead to a build up to critical levels during periods of inversions. Gases such as carbon dioxide, ammonia, mercury vapor, fluorine, radon, and other gases found associated with geothermal fluids in the area may, on occasion, could reach hazardous levels.

Lease stipulations or GRO Orders will be issued as appropriate to control emissions of gases beyond established health and safety standards if such gases are suspected of being hazardous and are not adequately covered by other regulations.

Most noxious and hazardous gases can be removed from the noncondensable gas fraction through chemical and mechanical means and successful methods are presently being employed in other industries to meet air-quality and health and safety standards. The technology, system, or economics of these processes may not, however, apply to geothermal power production processes. Research into new, less costly techniques for gas removal may be required to solve the potential emission

problems for power plants in the Imperial Valley area. Because of the lack of data on the make-up of the noncondensable gas fraction in this area, it can only be surmised that a problem may eventually exist. The mitigating measure required in the event that H<sub>2</sub>S levels prove unsafe or are in violation of State air-quality regulations probably would be chemical removal unless some other suitable process could be developed. (See further discussion of this subject in Volume I, Chapter III, Sections B and C, and the Geysers section of Volume II of this impact statement.)

Standards for noise and air contaminants, established under the Occupational Safety and Health Act of 1970, are described in the general statement. These standards as well as maximum permissible concentrations of radioactivity and Federal standards for airborne asbestos fiber exposures will apply to geothermal operations on proposed Federal leases in the Imperial Valley area. Establishment of any new health and safety or air-quality standards by the Federal or State Governments will be applicable to geothermal developments on Federal leases upon their promulgation.

Objectionable noise from geothermal activity is not regulated by any existing Federal or State laws. Lease stipulations regulating objectionable noise such as those outlined in the general statement may be attached to the lease, or appropriate GRO Orders will be issued after leasing has taken place. Noise standards for geothermal development as established by county ordinance will be adopted as appropriate by lease stipulation or GRO Orders. (The Imperial County standards are cited in the general statement.)

Several muffler designs have been successfully tested at existing geothermal fields. Similar muffling equipment will be required under GRO Orders or lease stipulation for use on wells on Federal leases. Continued improvements of muffling equipment for both wells and well drilling rigs is expected. Under existing technology, objectionable noise emissions as a result of geothermal development is not expected to be a serious problem.

Dust emissions from traffic movement over unimproved roads and from construction activity must be in compliance with State Highway standards and any GRO Orders or lease stipulations. Treatment of road surfaces with water, chemicals, or oil paving of roads may be required to control dust emissions to acceptable levels.

Burning of trash on Federal lands is regulated under provisions of 40 CFR 76, which may be supplemented by GRO Orders or lease stipulation. Geothermal activities generally are not expected to result in a serious fire hazard because of sparsity of flammable material in the desert environment.

Monitoring, as required by the operating regulations, will be used to define the quantities and types of atmospheric pollutants created by geothermal activities. Because of limited geothermal developments in the Imperial Valley area, present air-quality can be measured and used to indicate any air-quality degradation resulting from geothermal developments. Any measures, in addition to existing Federal and State standards, necessary to maintain the quality of the environment in the area will be included, as appropriate in leases as lease stipulations or issued as GRO Orders.

### 3. Vegetation

Potential impacts resulting from exploration and development are generally similar throughout the KGRA's in the Imperial Valley complex. Mitigation measures for these impacts generally would be similar to all vegetal communities but could vary by individual vegetation situations. Mitigation that applies to specific communities or sites is further described in this section.

Effective actions can be taken during exploration production phases to partially mitigate the impacts on the vegetal communities within the Glamis KGRA. For example, road construction to exploration sites can be designed to minimize disturbance of perennial woody vegetation. In the creosote and bajada communities, particularly, it may be appropriate for road alignment to meander through these types avoiding the destruction of mature plants. Sites or pads selected for drilling should be cleared with irregular perimeters and selected perennial vegetation should be left in place wherever possible within the pad area to preserve the integrity of the vegetal aspect. If such sites are not to be included in the development of the geothermal field, they should be revegetated to help reestablish the community aspect. Even under development, a certain amount of revegetation should be possible.

Drilling mud and brine ponds should be lined with butyl, polythelyne or other impervious materials to avoid the introduction of contaminants into local soils. These sites can be leveled and reseeded to native shrub species when they are no longer needed. Roads and drilling pads could be ripped and planted to appropriate species, thereby essentially returning the area to a natural condition.

Appropriate consideration will be given to areas of each major vegetal community to determine the extent to which there may be need to limit or exclude damaging occupancy to preserve the integrity of these systems. Significant sites, supporting botanically important species should be avoided. Under full development of the field, transmission and other powerlines should be established with a minimum of surface disturbance.

There also may be need to give special consideration to delicate seep and sink areas if external influences could destroy the intricate balance that is supported by these complex communities. When values are determined to be significant, appropriate protection measures will be imposed in lease terms or GRO Orders.

#### 4. Wildlife

Where there are similarities in fauna, mitigation of impacts upon the wildlife resources of the Imperial Valley KGRA's will be discussed collectively. Mitigation that can be identified with specific sites or habitat types is discussed separately.

The major impact on the wildlife resources will be felt through habitat deterioration or destruction. Adequate mitigation for the wildlife resources within these KGRA's will require additional studies and inventories as exploration and development progress. In many cases, most of what is known of the fauna is that certain species inhabit the area. Lack of information relative to critical habitats, animal values and distribution, and potential impacts of the various stages of geothermal development on specific habitat components may pose difficult problems relative to appropriate protection measures. For example, sites such as the seeps, sinks and the creosote forest may need to be left intact and representative areas of each habitat type may need to be excluded from exploration and development. Areas within the bajada and dunes creosote vegetal communities and their associated biological complexes should be selected and maintained in as undisturbed a condition as possible. These areas should be large enough so as to support all the biological components associated with them.

General provisions for the mitigation of impacts on biotic resources are discussed in Volume I, Chapter III, Section C of this environmental impact statement. These include considerations such as replacement of disturbed vegetation, land reclamation, prevention of electrocution of birds, public access to lease lands, and prevention of water pollution. When unacceptable adverse effects are found on wildlife in the Imperial Valley area, GRO Orders will be issued as appropriate to mitigate these impacts.

In order to minimize mortality of eagles, hawks, and other birds, power distribution lines are to be designed and constructed in accordance with REA Bulletin 61-10 (Powerline Contacts by Eagles and Other Large Birds).

Other measures also may be possible for prevention of electrocution bird losses. A feature article in the Wall Street Journal, (July 11, 1973) describes recent research relative to the prevention of eagle electrocution. It was found that a mature eagle

swoops under the outside wire of powerlines, then zooms upward with wings folded tightly to the body until it sets atop the crossarm, never touching two wires at once. By contrast, young eagles seem to fly awkwardly downward to the crossarm with their wings extended which may short out the two wires touched and electrocute the birds. The study indicates that by raising the center wire approximately 38 inches such contact can not be made. The cost of alteration estimated to be about \$100 to \$135 per pole. Other alternatives could include wrapping protective insulation around the center contact wire or constructing a special safe perch atop the pole.

Release of toxic or saline geothermal fluids to streams and the Salton Sea could have a severe impact on aquatic life; however, such releases are clearly prohibited under leasing and operating regulations, and are prohibited under orders of the Regional Water Quality Control Board. This is necessary to preserve the already threatened Sea from an uncontrolled increase in salinity. Enforcement of existing regulations should provide adequate protection for aquatic life from the impacts of geothermal development.

## 5. Archeological and Historic Values

Executive Order 11593, Protection and Enhancement of the Cultural Environment, May 13, 1971 (36 FR 8921), in furtherance of the purposes and policies of NEPA, the National Historic Preservation Act, the Historic Sites Act, and the Antiquities Act, asserts that "the Federal Government shall provide leadership in preserving, restoring, and maintaining the historic and cultural environment of the Nation"; directs Federal agencies to assure the preservation of cultural resources in Federal ownership, and "institute procedures to assure that Federal plans and programs contribute to the preservation and enhancement of non-federally owned sites, structures, and objects of historical, architectural, or archeological significance"; orders Federal agencies to nominate to the National Register all properties under their control or jurisdiction that meet the criteria for nomination; directs them to exercise caution to assure that cultural resources under their control are not inadvertently damaged, destroyed, or transferred before the completion of surveys to locate and identify properties worthy of nomination to the National Register; directs agencies to provide for recording of National Register properties that will be unavoidably altered or destroyed as a result of Federal action; directs agencies to undertake other measures to ensure the preservation of cultural resources under their control; and directs the Secretary of the Interior to undertake certain advisory responsibilities in compliance with the Order.

In the event there is evidence of significant archeological or historic values in areas to be leased in the Imperial Valley KGRA's provision will be made for appropriate surveys and historical research. Final location of project features should be based on data from these surveys. Highly significant archeological and historical resources should be avoided for construction sites. The requirements of E.O. 11593 will be followed for all resources which qualify for nomination to the National Register of Historic Places. Prior to construction adequate preservation or mitigation programs will be required as appropriate consistent with the archeological or historic values involved.

One significant archeological site located during the 1973 assessment should be considered for possible exclusion from exploration and production activities.

### a. Glamis (East)

This sector of the Glamis KGRA contains several extensive village sites located on desert pavement. Disturbance has occurred from quarrying operations north and south of Highway 78 in the past and is occurring at the present at an accelerating rate. Cultural context is being destroyed by scraping the top three to four inches of pavement aside to begin quarry sampling. In many portions of Glamis (east) several

feet of gravel have been removed. These village sites have not been recorded in the literature and prior to the 1973 assessment remained unknown. They offer an opportunity to recover pertinent data on the San Dieguito cultural complex.

In light of the unique potential for extensive archeological research in the Glamis (east) sector, geothermal exploration and development will allow for appropriate comprehensive study. In many instances, exploration and development activities could result in finds that otherwise would have remained unknown.

In accordance with Section 2(a) of the Executive Order 11593 to locate, identify, and nominate to the National Register all cultural resources under Federal control that meet the criteria for nomination; the following archeological and historical sites are in the process of nomination: (a) Glamis (east), a San Dieguito archeological village site located east of Glamis, California off Highway 78. This village site was primarily assessed for its scientific potential in June 1973 and found to be of extreme significance relating to the prehistory of the Imperial Valley specifically and to North American aboriginal occupation in general. Since this site is in immediate danger due to graveling operations nearby, necessary steps have been initiated to have this land excluded from the materials sale program administered by the Riverside District of the Bureau of Land Management, Department of the Interior. It also may be appropriate to limit or not permit geothermal exploration and development on this site.

b. East Mesa (west)

This sector is located 2 1/2 miles SE of Date City, California. This Yuma archeological site is quite extensive, yielding surface remains over an area in excess of 50 square yards. The constant occupation of this site over several hundred years up to the ethnographic present provides an opportunity for substantial scientific study. Although no threat to the integrity of this site is apparent, protective measures should be incorporated into any geothermal exploration or leasing activities involving this site.

Other archeological and historical sites located within the KGRA's will require further professional examination through survey and historical documentation procedures. It is anticipated that at least two other sites will be nominated to the National Register in the near future.

(1) Dune area SW of Glamis, California - this area was a known wagon train route west in the mid 1800's. Today complete wagons are periodically exposed by shifting sands near Osborn Lookout.

(2) Glamis Store; Glamis, California - owned and operated by Bill and Art Smith. This store and the Paper Doll House Saloon built in 1877 became a landmark and way-station for gold miners and travelers. The original store stands today, however, the saloon burned to the ground in the early 1900's. Other structures nearby include four railroad houses, now abandoned. This town was also headquarters for General George Patton during World War II prior to the North African campaign. The area was utilized by Patton's tank corps where extensive maneuvers in desert warfare were conducted.

As a part of the field assessment work conducted for preparation of this impact statement, an attempt was made to identify and delineate areas of relative archeological and historic importance within the Glamis, East Mesa and Dunes KGRA's. General descriptions of potential values have been previously discussed. Geothermal exploration and development activities could impact on such values to varied degrees. Such impacts could be favorable if they should result in additional discoveries, or they could be detrimental if they should damage or destroy things of value. Figure I-4 sets forth the general location and priorities. It must be recognized that this is preliminary information based upon limited surveys and the actual relationship to proposed geothermal development may have to be considered on an individual case-by-case basis.

For purposes of this evaluation relative to appropriate mitigating measures, the indicated priorities are:

Type 1 lands - Areas considered to be of such potential archeological significance as to warrant close control over significant terrain alteration. In some instances, total protection may be warranted.

Type 2 lands - Areas considered to be of high archeological significance. Specific surveys and investigations may be appropriate before significant geothermal developments begin.

Type 3 lands - Sectors of peripheral importance where geothermal operations might result in the discovery of archeological or historical features that would warrant further survey or special protection measures.

Type 4 lands - Areas with least potential adverse archeological or historic impact.

Appropriate provision will be included in lease stipulations and/or GRO orders to adequately provide for the protection and preservation of significant archeological or historic values. These will include on-site investigations and prompt notification of the supervisor of any indicated archeological or historic find resulting from exploration or development activities.

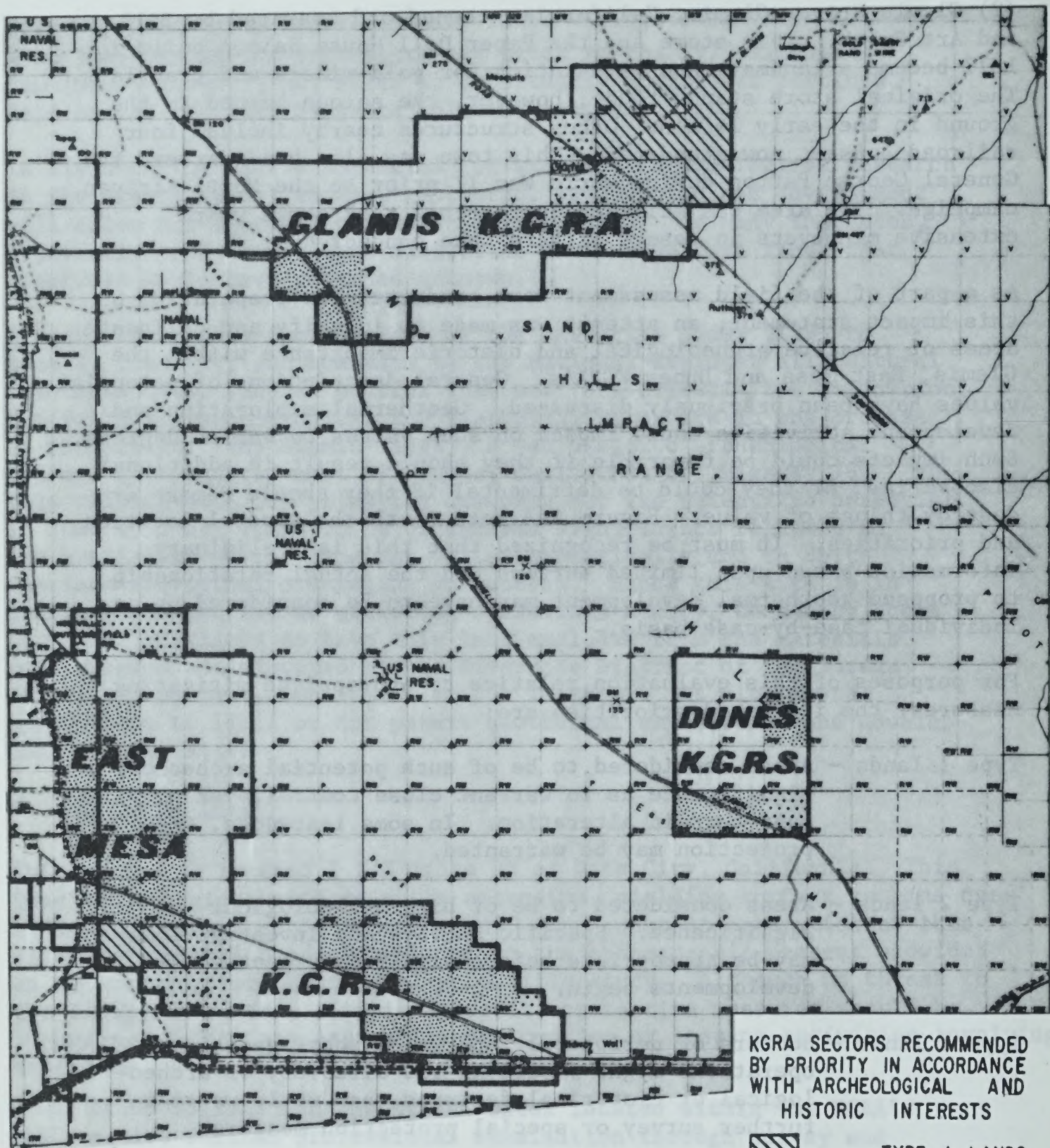


Figure I-4

KGRA SECTORS RECOMMENDED  
BY PRIORITY IN ACCORDANCE  
WITH ARCHEOLOGICAL AND  
HISTORIC INTERESTS



TYPE 1 LANDS



TYPE 2 LANDS



TYPE 3 LANDS



TYPE 4 LANDS

## 6. Recreation

The natural attributes of the Glamis KGRA and its associated plant and animal communities have important values to a large segment of the public. The Dunes KGRA also offers such qualities but to a somewhat lesser degree. In order to maintain these qualities, certain areas may warrant special consideration or be excluded from development. For example, it may be appropriate to maintain a buffer on either side of State Highway 78 to minimize the aesthetic impact. Special recognition may be required for the heavy impact of recreational use on the dune areas. Appropriate consideration will be given to such factors before development and plant construction plans are approved for inclusion of lease stipulations and GRO orders.

Production or other permanent facilities within the Glamis and Dunes areas should, to extent practical, be constructed and designed to minimize their visual intrusion. Color schemes, height of facilities and placement of pipe, powerlines and other required structures in developing this program should be designed to limit visual intrusion.

Recreation or aesthetic values in the East Mesa KGRA can be adequately protected through well planned and properly designed site development plans which could minimize the aesthetic degradation of this area, for both present and future recreational uses. In order to preserve the recreation values which exist in the Salton Sea KGRA, geothermal waste materials will not be permitted to be discharged into the Salton Sea. In order to minimize the adverse impacts of other necessary development features such as the construction of access roads, pipeline pads, and drilling sites, grouping or clustering will be considered. It might be feasible to use a single drilling pad or site, with several wells drilled at various angles to reach the desired locations, thereby reducing the surface impacts. Examples of other actions that will be taken as appropriate to mitigate potential impacts of development within the Salton Sea KGRA include (1) control of dust on developed or heavy-use areas; (2) placement of pipelines close to dikes or other already disturbed or compatibly developed areas; (3) aesthetically pleasing structures; and (4) the routing of transmission lines away from the Salton Sea in as short a distance as is feasible.

## 7. Minerals

No major conflicts or impacts are anticipated. However, if mitigation of impacts resulting from development of geothermal complexes upon sand and gravel deposits should be necessary, it could be accomplished by actions such as locating the geothermal structures away from known mineral deposits or by slant drilling.

The impact on sand and gravel, resulting from accidental brine spillage, could, if necessary, be mitigated by washing with water to remove the salts.

E. ADVERSE IMPACTS WHICH CANNOT BE AVOIDED SHOULD THE PROPOSAL BE IMPLEMENTED

Environmental Impacts will result from implementation of pre-leasing, leasing, and operational activities in the Salton Sea, Glamis, Dunes, and East Mesa KGRA's. Potential impacts and mitigating measures associated with such activities have been discussed in the preceding sections. (Also see Volume I, Chapter III, Section D)

The rules and regulations, lease provisions, and General Resources Operational Orders are designed to assure that geothermal resources can be developed and utilized in an environmentally acceptable manner. In those instances where this cannot be done, development and use will not be permitted. However, virtually any human use of lands and their resources may have some degree of adverse impact. Where benefits warrant acceptance of such impacts, such uses may be appropriate provided the adverse impacts have been adequately recognized, mitigated to the extent possible, and are not so serious as to preclude the proposed action. The following discussion summarizes the adverse impacts that may be unavoidable should the proposal be implemented in the Salton Sea KGRA, Glamis KGRA, Dunes KGRA and East Mesa KGRA, in Imperial Valley, California.

1. Exploration Phase

Exploration activities will involve physical presence upon the land which may result in damages to the land and resources thereon. Exploration activities include, but are not limited to, geophysical operations, drilling of shallow temperature gradient wells, construction of access roads or trails, and cross-country transit by foot, animals, or vehicles.

Even though persons conducting exploration operations comply with all of the general and specific terms and conditions of the "Notice of Intent to Conduct Exploration Operations," including the restoration of areas as near as possible to their original condition, some adverse impacts still may result. Examples are:

(a) Vehicle travel will result in dust, exhaust gases, noise, disturbance of wildlife, injury or killing of wildlife, accidents, etc. When existing roads are used, such impacts would be nominal since they primarily would be the result of increased traffic. Advance approval will be required for construction of new roads or trails to assure proper construction and restoration but impacts will result from vegetation removal and soil movement, even though adequate mitigating measures are taken. There will be a certain amount of disturbance of vegetative cover and soil surface from cross-country travel on roads or trails that can have temporary impacts until cover is restored and the soil is stabilized. Evidence of such roads or trails may remain for several years which could be conducive to casual use by others that could result in damage. Failure to comply with regulations or exploration stipulations could result in similar impacts, but damages could be more significant, particularly if such improper use was not

promptly detected and corrected. No serious unavoidable adverse environmental impacts are expected.

(b) Drilling of shallow holes or blasting may be necessary which may result in minor vegetative and surface disturbance in the immediate area of activity. All drill holes will be small and shallow and are to be capped when not in use so no damage is anticipated from such holes. If not capped, small animals could fall into the holes and perish. Large animals or man could step on open holes and be injured.

(c) Exploration of geothermal resources will have some unavoidable impacts upon the vegetal communities within the Salton Sea, Glamis, Dunes and East Mesa KGRA's. The impacts, of course, will vary depending upon the nature of exploration activities or the composition of the vegetal community. Those communities containing shrub species in moderate to heavy densities would be the most effected. In the creosote and bajada types, there could be some destruction of vegetation and compaction of soils, on those sites occupied by drilling rigs and roads.

## 2. Test Drilling Phase

Following award of leases, heavy equipment capable of drilling to depths of several thousand feet would be required. The enlargement and improvement of existing roads or construction of new roads to provide access for drilling equipment and supplies to the drilling site would involve unavoidable impacts from vegetative cover removal and surface disturbance. At each drilling site a level area of approximately one-half to one acre is required for drilling operations. While compliance with lease and GRO Orders will prevent serious adverse impacts, some minor impacts still will result. Most of the potential impacts listed under exploration could be expected with some intensification in areas of heavy activity.

During drilling operations, moderate levels of noise from equipment operations would be unavoidable. Even where special noise control measures are required, noise levels will be above natural levels.

Physical land modification will increase at this stage which could result in loss of wildlife forage and wildlife values in the areas of operation. Such impacts generally would be of a temporary nature. There could be some reduction of public use of areas for recreation, hunting, etc. during periods of test drilling activities to protect equipment and facilities, and to reduce hazards to the public. Surface disturbance scars would be larger and possibly permanent in nature.

Well blowouts could result in venting of steam, associated gases and saline water to the atmosphere, ground area and surface water, creating air and water contamination as well as high noise levels and exposing individuals to possible injury.

Adverse impacts would continue until the blowout is controlled. The seriousness of the incident could range from minor to serious, depending upon location.

In the event of an accidental discharge of geothermal brines at land surface in the Salton Sea KGRA, the brine will almost inevitably flow to the Salton Sea, thereby increasing the dissolved salts in the sea with potential impacts as previously described. The impact of degradation of surface water quality in any of the four KGRA's would be mainly in the effects on fish and wildlife and on salt concentration in soils.

### 3. Production Testing Phase

In a hot-water dominated reservoir at the Salton Sea, Glamis, Dunes and East Mesa KGRA's, production testing requires production of the formation fluid over an extended period. Disposal of produced brine would have an environmental impact released to the surface environment as discussed above. Large volumes of liquids could be involved. If not properly contained or reinjected, they could seriously impact on surface water quality and related fish, wildlife, or other water-related values.

### 4. Full-Scale Operation Phase

Full-scale operation will require complete development of well and steam transmission systems, power generation facilities, brine disposal facilities, transmission lines, permanent roads, etc. Many of the potential unavoidable adverse impacts associated with exploration and testing will no longer exist but other impacts may increase in proportion to the scale of development. Each well will involve clearing, grading, and improvements. Steam pipelines connecting wells to the generators likewise require clearing and grading. During construction, there will be considerable activity, noise, movement of earth, dust, etc. After construction is completed and all necessary environmental protection measures are taken, the nature of the site will be changed from its former state to an industrial complex. Cleared areas, buildings, power lines, brine ponds, etc., will represent permanent changes in the landscape.

Even with adequate controls, full-scale operations will involve higher than natural noise levels, emission of steam and other gases to the atmosphere, disturbance from operational activities, additional vehicle traffic, etc. Transmission lines will be a hazard to some wildlife as they may result in minor levels of electrocution of eagles, hawks, and other birds. Transmission lines damaged from storms or other failures can result in personal injury but to no greater extent than lines built in connection with other power systems under similar conditions.

Potential adverse impacts would be introduced during full-scale operation from possible land subsidence or increased seismic activity. However, a significant impact from these causes would not be expected until major production begins and appropriate mitigating measures would be taken as soon

as monitoring indicates a need for such actions.

If reinjection of wastes does not successfully maintain fluid pressures in the geothermal aquifer system where extractions are undertaken, some subsidence can be expected even if operations are discontinued.

The impacts of land subsidence and seismic activity will be mainly on structures - well casings, pipelines, canals, drainage systems, buildings, etc. Operations could have some unavoidable adverse impacts similar to those previously described upon the Salton Sea and land, vegetation, and associated fish and wildlife populations in the immediate vicinity of the wells, islands and/or drilling platforms, pipelines, generating plants, cooling facilities, power lines, pondage areas, recharge pipes, the associated work areas and roads, and buffer areas around the developments. Even with adequate controls, geothermal development could cause waterfowl and other bird populations to modify their use patterns on Salton Sea National Wildlife Refuge, The Wister Unit, and other areas in the sea.

Under full development of the Glamis field, the bajada and creosote communities, particularly the creosote forest community, could be drastically altered.

Some of the potential adverse effects on recreational use, natural values and aesthetics as discussed in previous chapters would occur. Though noise and gas emissions can perhaps be limited or avoided, little can be done to prevent the change from a wide-open natural setting to a partial industrial complex. There would be some reduction in outdoor leisure activities.

Leasing and operating regulations and GRO Orders will provide the necessary control mechanisms and safeguards to assure that environmental impacts of an adverse nature will be held to acceptable levels, but such levels will involve some adverse impacts.

F. THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USE OF MAN'S ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Leasing of Federal lands for geothermal resources development would involve commitment of a portion of the geothermal heat, water and land resources of the area for a period of 25 to 50 or more years. The extent of such commitments and the assessment of potential environmental impacts have been described in the preceding sections. The relationship between these short-term uses of the environment and the maintenance and enhancement of its long-term productivity also needs to be considered. This subject is discussed broadly in Volume I, Chapter III, Section E of this impact statement. Additional detail relative to the Imperial Valley KGRA's is included here.

By orderly development of the geothermal resources of the Imperial Valley for electrical generation, it would be possible to meet part of the growing Southern California electrical demand in a manner that appears to have minimal short and long-term effects on the productivity of the land or on its environment. This may be particularly so when one considers the total system environmental impacts of other alternative energy sources. (See Volume I, Chapter IV, Section 4 for a complete description of such alternatives and their potential environmental impacts).

Massive simultaneous development of all geothermal resources for maximum short-term benefits probably would be more wasteful of the total geothermal resource in the long-run than would be with a phased build-up of power capacity to a level that might be maintained almost indefinitely. Massive development also could have more severe short-term and long-term environmental consequences that could be reduced or avoided by a properly phased and carefully controlled development plan.

Experience at Wairakei, New Zealand has shown that geothermal development of a hot water field can stabilize at a rate of extraction that appears likely to continue indefinitely. Experience at Larderello, Italy has shown that geothermal development can be compatible with agricultural land use and need not produce industrial blight or seriously degrade aesthetics. Both the short and long-range benefits that may be derived from development of these resource potentials can be significant and reasonably compatible with related land use and environmental values.

Production of chemicals and fresh water as by-products of geothermal energy production would represent additions to these resources not presently available, with significant benefit potential. Bureau of Reclamation studies indicate that there could be significant benefits if Colorado River water supplies could be augmented by desalinization of geothermal fluids in this area. Multi-purpose fluids could result in extension of periods of economic productivity.

## 1. Water

Long term environmental impacts on water resources could involve depletion of gross water resources due to use by power plants and related facilities, degradation of water quality, land subsidence, and possible effects of induced seismic activity. However, depletion of gross water resources and degradation of water quality should not occur with properly managed extraction and injection systems. The temperature of geothermal zones used for extraction and injection could be cooled to the point where continued economic production would not be feasible. However, over time, through heat-transfer within the earth, temperatures may return to approximately existing levels. As previously indicated, it may be possible to operate balanced systems with virtually indefinite operating life.

Ground water in storage in fine-grained material, subject to compaction when pressure is relieved, is available for one-time use. In the event that land subsidence occurs, the storage capacity would be reduced by a volume equal to the volume of land subsidence.

## 2. Vegetation

The use of these areas for geothermal production will affect the vegetal communities during the period of occupancy. Restoration to as near the original natural state as possible will be required at time of abandonment. After the areas are abandoned, reestablishment of natural productive communities should occur in a relatively short time.

## 3. Fish and Wildlife

Geothermal development could have localized and regional adverse impacts on fish and wildlife resources and habitat. Long-term fish production could be reduced by the introduction of geothermal brine into the Salton Sea or through accidental spills of toxic fluids. Wildlife losses could be caused by loss of habitat, increased use and development. Fish and wildlife populations could return to their pre-development environment and population levels if sites are restored to near natural conditions.

Species which are rare or threatened due to low population levels could be vulnerable to extinction because of low numbers, restricted habitat, or some other habitat component.

## 4. Archeological and Historical Values

The development of geothermal resources, including exploratory testing, may commit terrain where archeological and historic resources are deposited. Archeological and historic values could be damaged or destroyed. However, development also could result in significant finds that otherwise might have gone undetected.

## 5. Land Uses

Land uses during the period of production operations would be changed to industrial operations from fish and wildlife habitat, recreation, agriculture, etc. However, many such uses could continue on a reduced compatible basis. Wells, pipelines, power plants, by-product facilities, and power transmission facilities would dominate the developed area. Public access in the vicinity of such facilities would have to be restricted to protect public safety and the facilities. Development and production of geothermal resources generally are not expected to have any lasting or inhibiting effects on the use of the land after geothermal operations have been concluded and the facilities have been removed.

Should geothermal production result in land subsidence, which is an irreversible process, the subsidence would constitute a long-term effect on the land resources. Such subsidence would not significantly affect use of the land in most areas except that changes in slope and elevation could affect rivers, canals, lowlands adjacent to the Salton Sea and engineering works. Such changes would represent a serious short-term impact on engineering structures but, in the long-term, could be accommodated by engineering modifications, mainly realignment and reconstruction of the affected structures or works. Significant costs could be associated with such corrective actions.

## 6. Recreation

The recreation and aesthetic impacts previously described would be present throughout the period of operation. Once production ends and the lands are restored, previous use could resume. Development could shift massive recreation use to other desert areas less suited to such uses. This problem could become particularly acute in the case of off-road vehicle use which could result in damage to areas of greater resource or environmental value.

## 7. Economic and Social

Geothermal development requires substantial investment in drilling wells, and construction of roads, pipelines, power and by-product plants, and transmission lines. Such investments result in an increased tax base for the area of development. The labor-intensive phase is short-term, during field development, and would not result in significant changes in the distribution of population or income. The economic benefits probably would be more in the nature of transfer benefits as a corresponding power generation capacity would have to be developed elsewhere if the geothermal resources were not developed.

There could be some aesthetic or social impacts in terms of increased noise levels, odors, additional traffic, etc., even though all of the environmental stipulations of the permits are met. These would be minor but objectionable in terms of pre-operational conditions. Since such operations could continue for a period of 25 to 50 years, they would exist during most of the lifetime of local residents or users of these areas.

G. ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION SHOULD IT BE IMPLEMENTED

Full development of the geothermal resources of the Imperial Valley would encompass extraction of thermal energy, dissolved mineral matter, and possible production of fresh water from thermal brines. The thermal energy stored in the brines presumably would be extracted at a rate equal to or greater than the natural terrestrial heat flow with power development based upon utilization of heat stored in the subsurface rocks and fluids over a long period of time. Although the terrestrial heat source will continue indefinitely, the use of the stored energy should be considered as a depletion of the thermal resource over the short-term. The dissolved minerals are not believed to be renewable and should be classed as a depletion of that resource, if it is utilized. However, minerals produced from this source would offset the need for corresponding production of like amounts from other areas.

The mechanism of recharge to the geothermal reservoirs of the Imperial Valley is poorly understood, but is presumed to be from rainfall on the drainage basins tributary to the Imperial Valley. Thus, water evaporated in geothermal production should be considered as a water consumption chargeable to the area. Injection waters obtained from other areas such as irrigation return flows, or even from the sea, could offset this gross consumptive charge. Since water is a renewable resource through the normal hydrologic cycle, this charge is not irretrievable. Compaction that may occur as a result of pressure decline is an irreversible process. Loss of porosity is a commitment of a resource, because this is the storage volume for the heat conducting fluid. Loss of storage capacity if subsidence occurs, loss of heat energy if cooling occurs, and losses related to seismic activities are irretrievable commitments if these activities are induced.

The capital and labor required for the geothermal development represent an irretrievable commitment of those resources, because installations would have little salvage value when the geothermal resources are exhausted.

Geothermal development would involve the creation of a semi-industrial complex in a presently remote natural or agricultural environment. Certain scenic landscapes with their associated vegetation, water, and wildlife habitat which provides recreational opportunities would be altered for decades; some might be lost permanently.

In the Salton Sea KGRA, annual fish and wildlife losses and fish and wildlife production forgone, over the entire life of the project are irretrievable commitments of resources, whether or not the affected species subsequently can be reestablished.

The construction and operation of the geothermal facilities would physically remove habitat used by fish and wildlife. The extent of loss is directly related to the amount of habitat destroyed and modified. The support development and associated urban development would entail localized temporary or permanent reduction of wildlife habitat and disturbance of populations.

If the water quality of the Salton Sea reaches 40,000 ppm of salt, the aquatic resource would be lost. There already is great concern over the rapidly increasing salinity resulting from the combination of irrigation return flows and high rates of surface evaporation. Any major accidental discharge of saline water would accelerate this problem.

## H. ALTERNATIVES TO THE PROPOSED ACTION

Volume I, Chapter IV of this impact statement discusses alternatives to the proposed leasing program and alternative electrical energy sources. As indicated in the introduction of the Imperial Valley section of this report, Stanford Research Institute in 1973 estimated an ultimate capacity of 3,000 MW, with less than 200 MW installed by 1985. The California Division of Oil and Gas has estimated 710 MW capacity by 1985 and San Diego Gas and Electric has estimated about 1,500 MW. This range represents the equivalent of one or two large fossil fuel or nuclear power plants. If the geothermal power resources of the area are not developed, an equivalent amount of electrical energy will have to be obtained from alternative sources. Private land holdings already are being explored and developed for geothermal power production in the Salton Sea area where most of the offshore lands within the KGRA are in private ownership. Portions of the land under the sea also are privately owned. There are private lands on the west side of the East Mesa KGRA. The Glamis KGRA is mostly public land and the Dunes KGRA is entirely public land. (Land ownership patterns are shown on the large scale map included in the pocket at the end of this volume.)

Alternatives as described in Volume I of this impact statement generally will not be repeated here. Major alternatives as they relate to these specific areas are:

### 1. No Leasing

There would be no exploration or development of Federally owned geothermal resources under this alternative. That portion of the potential geothermal generating capacity applicable to public lands would have to be provided from alternative sources. Potential production of fresh water or mineral by-products also would not materialize. Development of private lands could be even more intensive. Where private lands are adjacent to public lands, geothermal resources of the adjacent public lands could be depleted even though no development took place on the public lands. Surface environmental impacts associated with geothermal exploration and development would not occur if public lands were not leased but problems associated with potential subsurface effects, such as subsidence, could occur as a result of operations on adjacent private lands. The more intensive development of private land resources could result in less efficient overall use of geothermal resources of the area and could result in more severe environmental impacts as environmental requirements, restrictions and controls may not be as intensive and adequate as they would be for operations on Federal lands.

2. Lease only those lands that could or should be developed jointly with adjacent private lands

This alternative primarily would apply to leasing on the Salton Sea KGRA. It also could be applicable to the west side of the East Mesa KGRA. Under this alternative, Federal lands would be leased as a part of appropriate area development of private and public lands to provide for development units conducive to efficient and economic development and production.

The potential environmental impacts as previously discussed for these areas could occur to the extent that public lands were involved. Since similar impacts probably will occur from private land development in the same general area, the overall impacts involve acreage relationships. It is possible that inclusion of Federal lands in logical units actually could reduce potential impacts from private land development in that environmental stipulations and controls applicable to the public lands also could impact on the adjacent private land activity.

Under this alternative, no development would take place in the Dunes KGRA and there would be little possibility of development in the Glamis KGRA.

3. Lease only in the East Mesa KGRA

The potential for adverse environmental impacts from geothermal development are less in the East Mesa KGRA than they would be in the other KGRA's. Potential impacts on fish, wildlife and recreational uses in the Salton Sea KGRA are high. Recreational and archeological impacts could be high in the Glamis and Dunes KGRA's. The East Mesa KGRA is most suited to the imposition of mitigating measures that can minimize overall adverse environmental impacts. Details of potential impacts and of mitigating measures have been presented in detail in the appropriate sections of this statement.

4. Lease only lands of lowest environmental sensitivity in all KGRA's

As indicated throughout this environmental impact statement, leasing and development should not be permitted unless it can be accomplished in an environmentally acceptable manner. This option would be a further refinement in that leasing would be confined to those areas of lowest potential impact even though development of other areas could be accomplished in an environmentally acceptable manner. The environmental impacts of this alternative would be minimal. Resource development could be less efficient with increased costs resulting from elimination of prime development areas which might preclude development as there may be no direct relationship between the best geothermal reservoirs and surface values. Even though only portions of each KGRA would be impacted by development, many of the potential impacts could directly or indirectly effect adjacent areas. (Scenic, vehicle travel, power lines, etc.) Considerations primarily involve a matter of degree and intensity of impacts.

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PRELIMINARY PLANT SPECIES LIST OF THE  
GLAMIS, DUNES AND EAST MESA KGRAs

Common Names

Salt bush  
Palo verde  
Desert willow  
Croton  
Dalea  
Smoke tree  
Mormon tea  
Buckwheat  
Ocotillo  
Haplopappus  
  
Wild sunflower  
Creosote bush  
Ironwood  
Cholla cactus  
Palafoxia  
Arrow weed  
Mesquite  
Mesquite  
Screw-bean mesquite  
Globemallow  
Sand food  
Dicoria  
Sand verbena  
Popcorn weed  
Gramma grass  
Locoweed

Scientific Names

Atriplex canescens  
Cercidium floridum  
Chilopsis linearis  
Croton wigginsii  
Dalea emoryi  
Dalea spinosa  
Ephedra trifurca  
Eriogonum deserticola  
Fouquieria splendens  
Haplopappus acradenius ssp.  
eremophilus  
Helianthus tephrodes  
Larrea divaricata  
Olneya tesota  
Opuntia sp.  
Palafoxia linearis var. gigantea  
Pluchea sericea  
Prosopis glandulosa var. torreyana  
Prosopis juliflora var. torreyana  
Prosopis pubescens  
Sphaeralcea sp.  
Ammobroma Sonorae  
Dicoria canescens  
Mentzelia spp  
Chaenactis fremontii  
Bouteloua spp  
Astragalus megadalena

PRELIMINARY WILDLIFE SPECIES LIST OF THE  
GLAMIS, DUNES AND EAST MESA KGRAs

Common NamesScientific NamesAmphibians

Desert toad  
Couch's spadefoot toad

Bufo punctatus  
Scaphiopus couchi

Birds (Mostly Migrants)

White-throated swift  
Black-throated sparrow  
Black-chinned hummingbird  
Verdin  
Red-tailed hawk  
Swainson's hawk  
Costa's hummingbird  
Cactus wren  
House finch  
Turkey vulture  
Vaux swift  
Lesser nighthawk  
Raven  
Ladder-backed woodpecker  
Horned lark  
Prairie falcon  
Sparrow hawk  
Roadrunner  
Barn swallow  
Tree swallow  
Loggerhead shrike  
Gambel's quail  
Mockingbird  
Ash-throated flycatcher  
Cliff swallow  
Phainopepla  
Poor-will  
Albert's towhee  
Black-tailed gnatcatcher  
Black phoebe  
Say's phoebe  
Burrowing owl  
Crissal thrasher  
Le Conte's thrasher  
Western kingbird  
Gray vireo  
White-winger dove  
Mourning dove  
White-crowned sparrow

Aeronautes saxatalis  
Amphispiza bilineata  
Archilochus alexandri  
Auriparus flaviceps  
Buteo borealis  
Buteo swainsoni  
Calypte costae  
Campylorhynchus brunneicapillus  
Carpodacus mexicanus  
Cathartes aura  
Chaetura vauxi  
Chordeiles acutipennis  
Corvus corax  
Dendrocopos scalaris  
Eremophila alpestris  
Falco mexicanus  
Falco sparverius  
Geococcyx californianus  
Hirundo rustica  
Iridoprocne bicolor  
Lanius ludovicianus  
Lophortyx gambeli  
Mimus polyglottos  
Myiarchus cinerascens  
Petrochelidon pyrrhonota  
Phainopepla nitens  
Phalaenoptilus nuttallii  
Pipilo aberti  
Polioptila melanura  
Sayornis nigricans  
Sayornis saya  
Speotyto cunicularia  
Toxostomia dorsale  
Toxostoma lecontei  
Tyrannus verticalis  
Vireo vicinior  
Zenaida asiatica  
Zenaidura macroura  
Zonotrichia leucophrys

# PRELIMINARY WILDLIFE SPECIES LIST (Continued)

## Common Name

## Scientific Name

### Mammals

Coyote	<u>Canis latrans</u>
Antelope ground squirrel	<u>Citellus leucurus</u>
Round-tailed ground squirrel	<u>Citellus tereticaudus</u>
Desert Kangaroo rat	<u>Dipodomys deserti</u>
Merriam kangaroo rat	<u>Dipodomys merriami</u>
Black-tailed hare	<u>Lepus californicus</u>
Bobcat	<u>Lynx rufus</u>
Striped skunk	<u>Mephitis mephitis</u>
House mouse	<u>Mus musculus</u>
White-throated wood rat	<u>Neotoma albigula</u>
Southern grasshopper mouse	<u>Onychomys torridus</u>
Pocket mouse	<u>Perognathus arenarius</u>
Bailey pocket mouse	<u>Perognathus baileyi</u>
Short-eared pocket mouse	<u>Perognathus fallax</u>
Little pocket mouse	<u>Perognathus longimembris</u>
Desert pocket mouse	<u>Perognathus penicillatus</u>
Spiny pocket mouse	<u>Perognathus spinatus</u>
Deer mouse	<u>Peromyscus maniculatus</u>
Western harvest mouse	<u>Reithrojonotomys megalotis</u>
Audubon cottontail	<u>Sylvilagus auduboni</u>
Badger	<u>Taxidea taxus</u>
Pocket gopher	<u>Thomomys bottae</u>
Kit fox	<u>Vulpes macrotis</u>

### Reptiles

#### Lizards

Zebra-tailed lizard	<u>Callisaurus draconoides</u>
Western whiptail	<u>Cnemidophorus tigris</u>
Western banded gecko	<u>Coleonyx variegatus</u>
Leopard lizard	<u>Crotaphytus wislizeni</u>
Desert crested lizard (desert iguana)	<u>Dipsosaurus dorsalis</u>
Flat-tailed horned lizard	<u>Phrynosoma m'calli</u>
Desert horned lizard	<u>Phrynosoma platyrhinos</u>
Desert spiny lizard	<u>Sceloporus magister</u>
Colorado desert fringe-toed lizard	<u>Uma notata</u>
Long-tailed brush lizard	<u>Urosaurus graciosus</u>
Side-blotched lizard	<u>Uta stansburiana</u>

# PRELIMINARY WILDLIFE SPECIES LIST (Continued)

## Common Names

## Scientific Names

### Reptiles (Continued)

#### Snakes

Glossy snake	<u>Arizona elegans</u>
Branded sand snake	<u>Chilomeniscus cinctus</u>
Western shovel-nosed snake	<u>Chionactis occipitalis</u>
Western diamond rattlesnake	<u>Crotalus atrox</u>
Sidewinder	<u>Crotalus cerastes</u>
Spotted night snake	<u>Hypsignlena torquata</u>
Common wipsnake	<u>Masticophis flagellum</u>
Spotted leaf-nosed snake	<u>Phyllorhynchus decurtatus</u>
Gopher snake	<u>Pituophis melanoleucus</u>
Long-nosed snake	<u>Rhinocheilus lecontei</u>
Patch-nosed snake	<u>Salvadora hexalepis</u>
Western ground snake	<u>Sonora semiannulata</u>
Lyre snake	<u>Trimorphodon vandenburghi</u>

#### Turtles

Desert tortoise	<u>Gopherus agassizi</u>
Spring soft-shelled turtle	<u>Trionyx ferox</u>

# PRELIMINARY WILDLIFE SPECIES LIST (Continued)

## Invertebrates

### Scientific Names

### General Comments

#### SCORPIONS

##### Centruroides sculpturatus

Found only in a few places in California.

##### Hadrurus ariz. arizonensis x.

These hybrids are found only in the Algodones Dunes.

##### H. a. pallidis

Restricted to sand dunes.

##### Paruroctonus bergi

Found only in the Algodones Dunes and at Borrego.

##### P. berregoensis

Endemic?

##### P. luteolus

Not found at many other locations.

##### P. mesaensis

Endemic.

##### P. xanthus

Found only in sand dunes.

##### Vejovis coloradensis

Endemic?

##### V. hirsuticauda

Endemic.

##### V. (new species)

#### ORTHOPTERA

##### Arenivega sp.

Possibly an endemic species.

##### Centrophilus n. sp.

This large Camel Cricket is found only in these dunes.

#### THRIPS

##### Haplothrips n. sp.

Endemic.

#### COLEOPTERA

##### Acanthoscelidius, 2 new species

Endemic.

##### Anomala new species

Endemic new scarab.

##### Auleteus humeralis

Rare dune weevil.

##### Brachypsectra fulva

Rare beetle found in only a few places.

##### Coelosattus fortineri

Endemic genus and species of tenebrionidae.

##### Edrodes arens

Specialized, dune dwelling tenebrionid.

##### New Genus, new species

Endemic new scarab.

##### Pachyplectris laevis

Rare scarab.

##### Pseudocotalpa andrewsi

Endemic genus and species of scarab.

##### Trigonoscuta glamisae, new sub-species

Endemic.

##### T. nigromaculata (new species)

Endemic.

##### T. occidentalis (new species)

Endemic.

##### T. rothi algodones (new sub-species)

Endemic.

##### T. r. imperialis (new sub-species)

Endemic.

# PRELIMINARY WILDLIFE SPECIES LIST (Continued)

## Invertebrates (Continued)

<u>Scientific Names</u>	<u>General Comments</u>
COLEOPTERA (Cont.)	
<u>T. r. punctata</u> (new sub-species)	Endemic.
<u>T. rothi rothi</u> (new sub-species)	Endemic.
<u>Thysanocorynus</u> , 5 new species	Endemic.
<u>Xeropsamoboeus desertus</u>	Rare scarab.
HYMENOPTERA	
<u>Brachycistis convexus</u>	Endemic.
<u>Dasymutilla nocturna</u>	Rare dune dwelling velvetant.
<u>D. subhylina</u>	Endemic velvetant.
<u>Hadrocistis bicolor</u>	Endemic genus and species.
<u>H. slanskyae</u>	Endemic genus and species.
<u>Perdita algodones</u>	Endemic.
<u>P. frontalis</u>	Endemic.
<u>P. glamis</u>	Endemic.
<u>P. new species</u>	Endemic?
<u>P. pallida</u>	Rare nocturnal bee.
<u>Pogonomyrmex magnacanthus</u>	Endemic ant.
<u>Pheidole psammophila</u>	Endemic ant.
<u>Quenaya inermis</u>	Endemic.
<u>Q. new species</u>	Endemic.
DIPTERA	
<u>Caenotoides californica</u>	Endemic beefly.
<u>Lepidanthrax</u> , 3 new species	Endemic beeflies.
<u>Metacosmus elegans</u>	Rare, sand dune beefly.
<u>Therevid</u> spp.	These dunes are the type locality for many species of these flies. (See Irwin, Dissertation, 1971).
<u>Villa</u> , 10 new species	Endemic beefly.

## Salton Sea KGRA

## List of Plants and Wildlife

Appendix contains lists of flora and fauna that are commonly found in the vicinity of the KGRA. While intended to be representative of the types of plants and animals likely to be found in the area, they are not presented as containing every species that occurs.

TABLE I - Plants

<u>Common Name</u>	<u>Scientific Name</u>
Alkali goldenbush	<u>Haplopappus acradenius</u>
Burro-weed	<u>Franseria dumosa</u>
Arrow-weed	<u>Pluchea sericea</u>
Cheese bush	<u>Hymenoclea salsola</u>
Hairy-leaved sunflower	<u>Helianthus canus</u>
Brittle-bush, incienso	<u>Encelia farinosa</u>
Spanish needle	<u>Palafoxia linearis</u>
Fremont thornbush	<u>Lycium fremontii</u>
Narrow-leaved primrose	<u>Oenothera refracta</u>
Hairy sand verbena	<u>Abronia villosa</u>
Desert holly	<u>Atriplex hymenelytra</u>
Iodine bush	<u>Allenrolfea occidentalis</u>
Jimsonweed	<u>Datura discolor</u>
Plicate coldenia	<u>Coldenia plicata</u>
Alkali heliotrope	<u>Heliotropium curassavicum</u> var. <u>oculatum</u>
Creosote bush	<u>Larrea divaricata</u>
Puncture weed	<u>Tribulus terrestris</u>
Palo verde	<u>Parkinsonia aculeata</u>
Screwbean mesquite	<u>Prosopis pubescens</u>
Honey mesquite	<u>Prosopis juliflora</u>
Desert lupine	<u>Lupinus odoratus</u>
Indigo bush	<u>Parosela schottii</u>
Emory dalea	<u>Parosela emoryi</u>
Smoke tree	<u>Dalea spinosa</u>
Desert ironwood	<u>Olneya tesota</u>
Locoweed	<u>Astragalus</u> sp.
Ajamete	<u>Asclepias subulata</u>
Marsh fleabane	<u>Pluchea purpurascens</u>
Russian thistle	<u>Salsola Kali</u> var. <u>tenuifolia</u>
Inkweed	<u>Suaeda torreyana</u>
Narrow leaved wing scale	<u>Atriplex canescens linearis</u>
Quail brush	<u>Atriplex lentiformis</u>
Wheelscale	<u>Atriplex elegans fasciculata</u>

TABLE I - Plants (Continued)

<u>Common Name</u>	<u>Scientific Name</u>
Australian saltbrush	<u>Atriplex semibaccata</u>
Alkali blite	<u>Suaeda fruticosa</u>
Mule fat	<u>Baccharis viminea</u>
Seepwillow	<u>Baccharis glutinosa</u>
Broom baccharis	<u>Baccharis sarothroides</u>
Bassia	<u>Bassia hyssopifolia</u>
Sea purslane	<u>Sesuvium verrucosum</u>
Red stem	<u>Ammannia coccinea</u>
Catchfly gentian	<u>Eustoma exaltatum</u>
Aster	<u>Aster spinosus</u>
Wire grass	<u>Polygonum aviculare</u>
Curly dock	<u>Rumex crispus</u>
Dock	<u>Rumex violascens</u>
Desert thorn	<u>Lycium brevipes</u>
Mesquite	<u>Prosopis juliflora</u> var. <u>Torreyana</u>
Athel	<u>Tamarix aphylla</u>
Salt cedar	<u>Tamarix gallica</u>
Rabbitfoot grass	<u>Polypogon monspeliensis</u>
Timothy	<u>Phleum pratense</u>
Alkali sacaton	<u>Sporobolus airoides</u>
Common reed	<u>Phragmites communis</u>
Desert saltgrass	<u>Distichlis stricta</u>
Cereal ryegrass	<u>Lolium</u> sp.
Barley	<u>Hordeum vulgare</u>
Annual wild oat	<u>Avena fatua</u>
Millet	<u>Echinochloa crusgalli</u>
Mustard	<u>Brassica</u> sp.
Red sprangletop	<u>Leptochloa filiformis</u>
False daisy	<u>Eclipta alba</u>
Burhead	<u>Echinodorus cordifolius</u>
Sagittaria	<u>Sagittaria calycina</u>
Nut grass	<u>Cyperus difformis</u>
Alkali bulrush	<u>Scirpus robustus</u> & <u>Scirpus</u> <u>paludosus</u>
Common sunflower	<u>Helianthus annuus</u>
Sprangletop	<u>Leptochloa uninervia</u>

TABLE II - Fish

<u>Common Name</u>	<u>Scientific Name</u>
Orangemouth corvina	<u>Cynoscion xanthulus</u>
Sargo	<u>Anisotremus davidsoni</u>
Bairdiella (gulf croaker)	<u>Bairdiella icistia</u>
Striped mullet	<u>Mugil cephalus</u>
Threadfin shad	<u>Dorosoma petenense</u>
Desert pupfish	<u>Cyprinodon macularius</u>
Sailfin molly	<u>Poecilia latipinna</u>
Longjaw mudsucker	<u>Gillichthys mirabilis</u>
Mosquitofish	<u>Gambusia affinis</u>
Red shiner	<u>Notropis lutrensis</u>
California killifish	<u>Fundulus parvipinis</u>

TABLE III - Mammals

<u>Common Name</u>	<u>Scientific Name</u>
Desert cottontail	<u>Sylvilagus auduboni arizonae</u>
Blacktail hare	<u>Lepus californicus deserticola</u>
Coyote	<u>Canis latrans clepticus</u>
Raccoon	<u>Procyon lotor pallidus</u>
Bobcat	<u>Lynx rufus baileyi</u>
Desert kangaroo rat	<u>Dipodomys deserti deserti</u>
Striped skunk	<u>Mephitis mephitis holzneri</u>
Muskrat	<u>Ondatra zibethicus bernardi</u>
Badger	<u>Taxidea taxus berlandieri</u>
Desert kit fox	<u>Vulpes velox</u>
Gray fox	<u>Urocyon cinereoargenteus scotti</u>
Roundtail ground squirrel	<u>Citellus tereticaudus tereticaudus</u>
Valley pocket gopher	<u>Thomomys bottae albatrus &amp; Crass</u>
Desert pocket mouse	<u>Perognathus penicillatus angustirostris</u>
Deer mouse	<u>Peromyscus maniculatus gambelii</u>
Desert shrew	<u>Notiosorex crawfordi crawfordi</u>
California myotis	<u>Myotis californicus stephensi</u>
Western pipistrel bat	<u>Pipistrellus hesperus hesperus</u>
Little pocket mouse	<u>Perognathus longimembris bangsi</u>
Desert woodrat	<u>Neotoma lepida gilva</u>
Whitethroated woodrat	<u>Neotoma albigula venusta</u>
Norway rat	<u>Rattus norvegicus</u>
Black rat	<u>Rattus Rattus</u>
House mouse	<u>Mus musculus</u>
California leaf-nosed bat	<u>Macratus californicus</u>
Long-tongued bat	<u>Choeronycteris mexicana</u>

TABLE III - Mammals (Continued)

Common NameScientific Name

Western yellow bat

Lasiurus gervais

Hoary bat

Lasiurus cinereus

Big brown bat

Eptesicus fuscus

Spotted bat

Euderma maculata

Pallid bat

Antrozous pallidus

Brazilian free-tailed bat

Tadarida brasiliensis

Pocketed free-tailed bat

Tadarida femorosacca

Big free-tailed bat

Tadarida molossa

Antelope ground squirrel

Ammospermophilus leucurus

Spiny pocket mouse

Perognathus spinatus

Merriam kangaroo rat

Dipodomys merriami

Cactus mouse

Peromyscus eremicus

TABLE IV - Birds 1/

Common NameScientific Name

Eared grebe

Podiceps caspicus

Western grebe

Aechmophorus occidentalis

Pied-billed grebe

Podilymbus podiceps

White pelican

Pelecanus erythrorhynchos

\*Brown pelican

Pelecanus occidentalis

Double-crested cormorant

Phalacrocorax auritus

Great blue heron

Ardea herodias

Green heron

Butorides virescens

Common egret

Casmerodius albus

Snowy egret

Leucophoyx thula

TABLE IV - Birds (Continued)

<u>Common Name</u>	<u>Scientific Name</u>
Marsh hawk	<u>Circus cyaneus</u>
Osprey	<u>Pandion haliaetus</u>
*American peregrine falcon	<u>Falco peregrinus anatum</u>
Prairie falcon	<u>Falco mexicanus</u>
Pigeon hawk	<u>Falco columbarius</u>
Sparrow hawk	<u>Falco sparverius</u>
Ring-necked pheasant	<u>Phasianus colchicus</u>
California quail	<u>Lophorlyx californicas</u>
Gambel's quail	<u>Lophortyx gambelii</u>
Sandhill crane	<u>Grus canadensis</u>
*Yuma clapper rail	<u>Rallus longirostris yumanensis</u>
Virginia rail	<u>Rallus limicola</u>
Sora	<u>Porzana carolina</u>
California blackrail	<u>Laferallus jamaicensis coturniculus</u>
Common gallinule	<u>Gallinula chloropus</u>
American coot	<u>Fulica americana</u>
Semipalmated plover	<u>Charadrius semipalmatus</u>
Snowy plover	<u>Charadrius alexandrinus</u>
Killdeer	<u>Charadrius vociferus</u>
Mountain plover	<u>Eupoda montana</u>
Black-bellied plover	<u>Squatarola squatarola</u>
Common snipe	<u>Capelia gallinago</u>
Long-billed curlew	<u>Numenius americanus</u>
Whimbrel	<u>Numenius phaeopus</u>
Spotted sandpiper	<u>Actitis macularia</u>
Solitary sandpiper	<u>Tringa solitaria</u>
Willet	<u>Catoptophorus semipalmatus</u>
Greater yellowlegs	<u>Totanus melanoleucus</u>
Lesser yellowlegs	<u>Totanus flavipes</u>
Pectoral sandpiper	<u>Erolia melanotos</u>
Least sandpiper	<u>Erolia minutilla</u>
Dunlin	<u>Erolia alpina</u>
Knot	<u>Calidris canutus</u>
Long-billed dowitcher	<u>Limnodromus scolopaceus</u>
Stilt sandpiper	<u>Micropalama himantopus</u>
Western sandpiper	<u>Ereunetes mauri</u>
Marbled godwit	<u>Limosa fedoa</u>
American avocet	<u>Recurvirostra americana</u>
Black-necked stilt	<u>Himantopus mexicanus</u>
Wilson's phalarope	<u>Steganopus tricolor</u>
Northern phalarope	<u>Lobipes labatus</u>
Red phalarope	<u>Phalaropus fulicarius</u>
Herring gull	<u>Larus argentatus</u>
California gull	<u>Larus californicus</u>
Ring-billed gull	<u>Larus delawarensis</u>

TABLE V - Amphibians and Reptiles

<u>Common Names</u>	<u>Scientific Names</u>
<u>Amphibians</u>	
Southwestern woodhouse's toad	<u>Bufo woodhousei</u>
Red-spotted toad	<u>Bufo punctatus</u>
Bullfrog	<u>Rana catesbeiana</u>
<u>Reptiles</u>	
Desert tortoise	<u>Gopherus agassizi</u>
Spring softshell	<u>Trionyx spinifews</u>
Zebra-tailed lizard	<u>Collisaurus draconoides</u>
Western blind snake	<u>Leptotyphaleps humilis</u>
Spotted leaf - noster snake	<u>Phyllochynchus decurtatus</u>
Coachwhip	<u>Masticophis flagellum</u>
Desert patch-nosed snake	<u>Salvadora hexalepis</u>
Sonora gopher snake	<u>Pituophis melanoleucus</u>
Desert glossy snake	<u>Arizona elegans</u>
Kingsnake	<u>Lampropeltis getulus</u>
Western long-nosed snake	<u>Rhinocheilus lecontei</u>
Checkered garter snake	<u>Thamnophis marcianus</u>
Western ground snake	<u>Sonora semiannulata</u>
Colorado desert shovel-nosed snake	<u>Chionactis occipitalis</u>
Night snake	<u>Hypsiglena torquata</u>
Western whiptail lizard	<u>Cnemidophorus tigris</u>
Desert iguana	<u>Dipsosaurus dorsalis</u>
Western rattlesnake	<u>Crotalus viridis</u>
Sidewinder rattlesnake	<u>Crotalus cerastes</u>
Banded gecko	<u>Coleonyx variegatus</u>
Chuckwalla	<u>Sauromalus obesus</u>
Fringe-toed lizard	<u>Uma inornata</u>
Collared lizard	<u>Crotaphytus collaris</u>
Long-nosed leopard lizard	<u>Crotaphytus wislizenii</u>
Flat-tailed horned lizard	<u>Phrynosoma m'calli</u>

1/ Bird list contains 213 species that have been recorded by personnel of the U. S. Fish and Wildlife Service, California Department of Fish and Game, and many visiting ornithologists. This list, using species names, is in accordance with the A.O.U. Check-List. Where new names are sufficiently different, the former name is added in parentheses.

\* Endangered species.

BLM  
RECREATION USE SURVEY  
SOUTHEAST DESERT RESOURCE AREA

Attached is a compilation of data resulting from a recreation use survey in the Southeast Desert Resource Area, April 14-15, 1973.

There are 8,500 people in the area, including 3,500 participants and spectators at five ORV events. It has a two day weekend marred by high winds and blowing dust, yet at least 34,000 visitor use days occurred.

By contrast, an aerial count on Washington's Birthday weekend (February 17-19, 1973) revealed 20,000 people and 120,000 visitor use days for three days.

From this year's data, and that of previous studies, we can derive a pretty good annual estimate of the magnitude of recreation use in that Resource Area:

(a) During the heavy use season (September - May) there are two major "four day" weekends - Thanksgiving and New Year's Day - that represent peak use for the year. Thanksgiving counts in October 1970, showed 7,335 vehicles in the Imperial Sand Dunes only. New Years 1971 showed 5,635 in the Dunes. (See Imperial Dunes Management Plan, Charts A-1, and A-2).

An ultra-conservative current estimate, based on the above, would show 8,000 vehicles in the Dunes on Thanksgiving, 1972, and 6,000 vehicles on New Year's 1973.

We know that the use in the Dunes represents a little more than 50% of the total use for on the entire Resource Area. For instance, a 1973 Washington's Birthday count showed 2,665 vehicles in the Dunes, and 5,000 for the whole area.

Therefore, current Thanksgiving use figures for the Resource Area would be:

16,000 (vehicles) x 4 (people per vehicle) = 64,000

64,000 x 8 VUDs = 512,000 VUDs

For New Year's it would be 12,000 (vehicles) x 4 (people per vehicle) = 48,000

48,000 x 8 VUDs = 384,000 VUDs

For those two weekends the total use is 896,000 VUDs in the Resource Area.

(b) Easter weekend, 1971, had 4,830 vehicles in the Dunes, and 1973's extrapolation would be:

$5,000 \times 2 = 10,000$  vehicles

$10,000 \times 4$  people/car = 40,000 people

$40,000 \times 8$  VUDs = 320,000 VUDs for Easter

(c) Four other major three day weekends occur during the September-May heavy use season. Using representative three day weekend use figures for this year (Washington's Birthday):

$120,000$  VUDs  $\times 4 = 480,000$  VUDs

(d) Normal two day weekend figures, again 1973's, are 34,000 VUDs. There are 29 such weekends in the heavy use season.

$29 \times 34,000$  VUDs = 986,000 VUDs

(e) Average weekday use for the same period in the Resource Area is a minimum of 200 vehicles, or 800 people. (Chart A-2 of management plan shows a higher average, for the Dunes only, even in 1970-71).

$158$  days  $\times 800$  people  $\times 2$  VUDs/day = 152,800

(f) Figures for the hot season (June-August) are unavailable. Use of course, is occurring, even night ORV activities on the Dunes. Rather than guess we will not add any use figures for this period.

TOTAL annual use in the Southeast Desert Resource Area = a + b + c + d + e + f.

$896,000 + 320,000 + 480,000 + 986,000 + 152,800 + 0 = 2,834,800$  VUDs

There are 12 million acres of public domain in the desert. The above discussion relates to 1/6 of that total area. What is the use on the other 5/6? We do not have accurate figures comparable to intensive surveys made in the Southeast Desert Resource Area. But from past experience and general observations, the desert might be receiving an estimated 4 times the use of the S.E. Desert Area.

$4 \times 2,834,800 = 11,336,000$

That requires substantiation or amendments based on reliable surveys over the entire desert.

## DESERT USE SURVEY

Southeast Desert Resource Area

April 14 - 15, 1973

An aerial count showed 2,100 vehicles, representing 8,400 recreationists (at four/vehicle).

As part of the survey 161 users were interviewed, with the following results:

### Type of Party Interviewed:

Family	-	58
Friends	-	86
Individual	-	5
Club	-	<u>12</u>
		161

### Number in Party Interviewed:

1 - 4	13 - 4	25 - 3
2 - 20	14 - 4	26 - 1
3 - 10	15 - 2	28 - 3
4 - 20	17 - 3	30 - 3
5 - 13	18 - 1	32 - 1
6 - 10	19 - 1	34 - 1
7 - 5	20 - 1	35 - 1
8 - 4	21 - 1	37 - 1
9 - 7	22 - 3	45 - 1
10 - 6	23 - 1	75 - 1
11 - 6	24 - 1	1,400 - 1
12 - 4		

Average Group Size - 9 (excluding the 1,400 people at one ORV race).

There were 2,929 people represented in the groups from which 161 interviews were taken.

### Age Groups of Users

Under 12 years of age	760
13 - 19	532
20 - 45	1,292
45 +	<u>337</u>
	2,929

### Length of Visit

Under 12 Hours	- 11	120	- 2
12	- 4	144	- 1
24	- 21	156	- 1
36	- 22	163	- 5
48	- 59	240	- 3
60	- 1	336	- 4
72	- 12	152	- 1
96	- 15		

### Transportation to Site

Pickup	- 93
Motor Home	- 19
Sedan	- 28
4-WD	- 9
Van	- 15
Other	- 2

### ORV Brought

Cycle	- 66
4-WD	- 30
Dune Buggy	- 37
None	- 44
Horse	- 1

### Camping Set-Up

Camper	- 65
Trailer	- 32
Tent	- 20
Motor Home	- 16
In Vehicle	- 15
Sleeping Bag	- 7
Day Use	- 12

### Origin

Los Angeles Area	- 76
San Diego Area	- 62
Local	- 16
San Jose	- 1
Idaho	- 1
Portland	- 1
Stockton	- 1

### Driving Time to Site

Less than 1 Hour	- 3	5	- 17
1	- 14	6	- 2
2	- 40	7	- 1
3	- 46	9	- 9
4	- 30	12	- 1

### Learned of Site Through

Friends	- 107
Signs	- 2
Maps	- 7
Looking around	- 33
Mass Media	- 22

### Destination

Present Site	- 146
Transient	- 13

### Self-provided Toilet (in vehicle or portable)

Yes	- 90
No	- 71

### Frequency of Visits

The interviewee's total annual visits to the desert was 1,324 - an average of 8 visits/party.

### Economic Data

The interviewees reported they had spent a total of \$7,092 for the weekend. Of that total, \$3,440 was spent locally in the resource area counties.

Average expenditure was \$44 for the weekend.

### Visitor Use Days

For the 161 interviews 13,366 visitor use days (12 hours) were used.

## DESERT USE SURVEY

On February 19-21, 1972 (Washington's Birthday weekend), a combined aerial and ground count showed an estimated 15,000 recreationists on the Southeast Desert Resource Area's 2,350,000 acres.

As part of the survey 121 users were interviewed, with the following results:

### Type of Party Interviewed:

Family Group	-	104	(86%)
Friends	-	6	
Single	-	4	
Other	-	7	

### Number in Party Interviewed:

2	-	41	(34%)
4	-	23	(19%)
3	-	15	(12%)
5	-	15	
6	-	7	
1	-	6	
10	-	5	
7	-	3	
8	-	2	
21	-	1	
22	-	1	

There were 491 people in the 121 groups interviewed.

### Age Groups of Users:

20 - 45 years old	-	206	(42%)
Under 12	-	125	(25%)
13 - 19	-	91	(19%)
45 +	-	69	(14%)
		<u>491</u>	

### Average Party Size:

4

Primary Recreational Activity:

ORV	-	42
Camping	-	26
Rockhounding	-	23
Sight-seeing	-	11
Hiking	-	9
Loafing	-	7
Picnicking	-	3
Exploring	-	1

User's Origin by County:

San Diego	-	48
Los Angeles	-	29
Riverside	-	9
Orange	-	7
San Bernardino	-	7
Mendocino	-	2
Imperial	-	2
Sacramento	-	1
Modoc	-	1
Napa	-	1
Ventura	-	1
Out-of-State	-	10

(Nevada, Oregon, Canada, Iowa, Utah,  
Washington, Arizona)

Learned of Site Through:

Friends	-	68
Magazine	-	16
Roaming	-	11
Club	-	9
Grew up locally	-	9
Local Inquiry	-	5
Other	-	8

Transportation to Site:

Pickup	-	71
Sedan	-	28
Motor Home	-	21
4 WD	-	12

Recreation Vehicle Used:

Cycle	-	51
None	-	33
Dune Buggy	-	21
4 WD	-	17
Other	-	7
Total		129

Camping Set-Up:

Camper	-	60
Trailer	-	22
Tent	-	15
Motor Home	-	14
Sleeping Bag	-	9
None (Day Use)	-	2

Self-Contained:

No	-	56
Yes	-	50

Length of Visit:

3 days	-	64
2 days	-	31
3 +	-	20
Less than 1	-	5

Frequency of Visits:

0 - 5/year	-	45
6 - 10/year	-	24
15 +/year	-	22
11 - 15/year	-	13

Destination:

Present Site	-	110
Transient	-	7

## Economic and Total Use Data:

A total of \$10,563 was spent by the 121 groups, and of that amount \$2,851 was spent locally.

For the 491 people in the 121 groups, a total of 4,116 visitor use days (12 Hours) were tabulated. Applying this to the 15,000 visitors in the area (via ratio and proportion) about 125,500 VUD's are estimated for the whole resource area for that weekend.

At the average expenditure of \$2.57/VUD the total amount expended by the 15,000 people was about \$322,500 for the weekend. Of that, about \$87,000 was spent locally in the counties involved.

## Visitor Dislikes:

None	- 58
Lack of facilities	- 31
ORV's	- 19
Crowds	- 7
Crime	- 6
Other	- 10

## Known Unsafe Conditions:

None	- 70
Roads	- 11
Natural Hazards	- 11
Unsupervised kids	- 5
Other	- 10

## Experienced or Witnessed Crime:

None	- 90
Robbery	- 6
Dope	- 3
Other	- 2

## Crime Witnessed or Experienced by Friends:

No	- 83
Robbery	- 15
Dope	- 3
Other	- 2

## Suggestions:

Leave Desert the way it is	- 37
Trash pickup	- 28
Toilets	- 17
None	- 13
Water	- 7
Signs	- 7
Showers	- 7
Roads	- 6
Patrols	- 6
Campgrounds	- 5
Dump Stations	- 5
Other (Miscellaneous)	- 27

The study resulted in several suggestions for improvement of the interview forms, as well as study organization.

Future studies will include a modified form, a "cook-booked" instruction session for interviewers, and adequate statistical sampling techniques to derive more valid and universal data on desert use.

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6160

STATE OFFICE  
2800 Cottage Way - Room E-2841  
Sacramento, California 95825

Feb. 9, 1972

Memorandum

To: District Manager, Riverside

From: Chief, Division of Resources

Subject: Visitor Use Surveys - Imperial Sand Dunes

Attached is a compilation of visitor use data gathered over the past couple of years.

No attempt was made to derive sophisticated statistical conclusions. The questionnaire used, and variance in interview techniques, introduced bias in several areas.

However, the basis information contained here is obviously of value and can be applied to the data bank we are beginning to accumulate in support of management decisions.

Not included on the attached compilation are several inferences drawn from other questions used on the forms. For instance, a question on hazards evoked numerous and varied responses, with the predominant being "congestion on highways, speeding, reckless driving, unsupervised children and litter (broken glass, etc.)."

As for the reason visitors come to the desert, the predictable answer was most usually "to relax and get away from it all"-- or some variation.

Also, a noticeable number of interviewees noted they would like to see the desert left "as is, unrestricted to use, etc." An equally noticeable number noted the need for litter control, bathrooms, better roads, etc.

A. E. Smith

Attachment

Acting

RCCrawley:ew  
2/9/73

# IMPERIAL SAND HILLS VISITOR USE SURVEYS

		Thanksgiving Weekend 1970		New Years Weekend 1971		Thanksgiving Weekend 1971		Combined Surveys	
		<u>No.</u>	<u>%</u>	<u>No.</u>	<u>%</u>	<u>No.</u>	<u>%</u>	<u>No.</u>	<u>%</u>
(1)	<u>Form Completed</u>								
	<u>By:</u>								
	Head of Family	113	76	82	71	55	79	250	75
	Individual	25	17	34	29	7	10	66	20
	Organized Group Leader	11	7	---	--	8	11	19	5
		<u>149</u>		<u>116</u>		<u>70</u>		<u>335</u>	
(2)	<u>Ages:</u>								
	To 12	266	28	125	28	125	17	516	28
	13 - 19	193	20	55	12	56	12	304	16
	20 - 45	412	43	217	48	263	56	892	48
	45 +	79	8	49	11	25	5	153	8
		<u>950</u>		<u>446</u>		<u>469</u>		<u>1,865</u>	
(3)	<u>Origin:</u>								
	California	49	98	77	70	70	97	196	84
	Arizona	1	2	33	30	2	3	36	16
		<u>50</u>		<u>110</u>		<u>72</u>		<u>232</u>	
(4)	<u>Vehicle Used For Transportation</u>								
	<u>To Desert:</u>								
	Pickup/Camper	74	41	81	57	49	38	204	45
	Pickup	39	21	16	11	7	5	62	14
	Motor Home	13	7	10	7	25	19	48	11
	Sedan	22	12	8	6	15	12	45	10
	4-WD	12	7	13	9	17	13	42	9
	Dune Buggy	17	9	4	3	10	8	31	7
	Cycle	5	3	1	--	4	3	10	2
	Auto/Trailer	---	--	7	5	3	2	10	2
	Airplane	---	--	1	--	---	--	1	--
		<u>182</u>		<u>141</u>		<u>130</u>		<u>453</u>	
(5)	<u>Recreation Vehicle Used in Desert:</u>								
	Dune Buggy	113	66	97	63	65	59	275	63
	Cycle	47	27	23	15	29	26	99	23
	None	2	1	33	22	2	2	37	8
	4-WD	9	5	---	--	15	14	24	6
	Sedan	1	--	---	--	---	--	1	--
		<u>172</u>		<u>153</u>		<u>111</u>		<u>436</u>	

	Thanksgiving Weekend 1970		New Years Weekend 1971		Thanksgiving Weekend 1971		Combined Surveys	
	No.	%	No.	%	No.	%	No.	%
(6) <u>Length of Stay:</u>								
Less Than 24 Hrs.	4	4	---	--	2	3	6	2
24 - 47	4	4	5	5	9	12	18	6
48 - 71	24	22	18	17	18	23	60	21
72 - 95	41	37	60	58	28	36	129	44
96 +	38	34	20	19	20	26	78	27
	<u>111</u>		<u>103</u>		<u>77</u>		<u>291</u>	

(7) <u>Frequency of Visits:</u>								
2 - 3/Yr.	38	28	53	52	25	33	116	37
1/Mo.	63	46	20	20	26	34	109	35
2/Mo.	19	14	2	2	16	21	37	12
1st Time	6	4	9	9	3	4	18	6
1/Yr.	---	--	17	17	---	--	17	5
1/Week	10	7	1	1	2	3	13	4
4 - 5/Yr.	---	--	---	--	2	3	2	1
6/Yr.	---	--	---	--	2	3	2	1
7 - 8/Yr.	1	--	---	--	---	--	1	--
	<u>137</u>		<u>101</u>		<u>76</u>		<u>315</u>	

(8) <u>Activities Participated In:</u>								
Dune Buggy	114	32	99	33	68	29	281	32
Camping	104	29	76	26	69	30	249	14
Sightseeing	55	15	36	12	33	14	124	14
4-WD	13	4	28	9	15	6	56	6
Picnicking	21	6	17	6	17	7	55	6
Hiking	22	6	14	5	20	9	56	6
Rockhounding	21	6	8	3	6	3	35	4
Cycling	11	3	16	5	2	1	29	3
Photography	---	--	1	--	---	--	1	--
Fishing	---	--	1	--	2	1	3	--
Hunting	---	--	1	--	---	--	1	--
	<u>361</u>		<u>297</u>		<u>232</u>		<u>890</u>	



## CHAPTER VI

### COMMENTS AND RESPONSES ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

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## CHAPTER VI

### COMMENTS AND RESPONSES ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

#### A. GENERAL

Comment California Farm Bureau Federation, I-183

The tone of the statement seems to be negative and may result in unnecessary delay in development of the resource.

#### Response

The Environmental Impact Statement is designed to realistically identify and assess potential beneficial and detrimental impacts which may result from the actions proposed. Since virtually any beneficial use of lands or natural resources can have some degree of adverse impacts, the discussion of such potentials, many of which may be nominal or may not even materialize, tends to leave a negative impression. Accordingly, reviewers first must recognize the benefits to be derived from meeting energy requirements in an environmentally acceptable manner. Such benefits are set forth in various discussions of energy requirements and alternatives in the final Environmental Impact Statement. The purpose of the document is to attempt to set forth the facts so that they can appropriately be considered in the action decision process rather than to serve as a justification or promotional document.

Comment Center for Law and Policy, I-249

Maps should show the relationship between the specific location of Federal and private geothermal areas.

#### Response

Large-scale maps showing land ownership, usage patterns and proposed lease tracts for The Geysers, Mono Lake-Long Valley and Imperial Valley have been included in a pocket at the end of Volume II of the final statement.

Comment Geological Survey, I-47

The usefulness of the maps is lessened by the inclusion of the legend and name of the map in the areas of special interest.

#### Response

The maps have been modified so that the legend does not obscure data. In addition, large-scale maps of the three areas have been included in a pocket at the end of Volume II of the statement.

The Department recognizes in the draft statements the need for additional scientific studies aimed at monitoring some environmental impact, including those related to ground water, seismicity, subsidence, landslides, surface water and air pollution. Specific categories of studies, types of measurements, and general monitoring procedures, plus the responsibility for funding and initiating such studies, should be discussed in detail in the draft statement and expressly set forth in the regulations.

Response

The final environmental statement discusses more fully some of these research efforts, particularly in relation to seismicity, subsidence, noise and air pollution. Additional research information has been included in the discussions of alternatives. The regulations now include provisions for monitoring by the operator or Federal Government. Research will be aided by data from geothermal operations in three areas proposed for the initial leasing program.

Comment Center for Law and Social Policy, I-249

If current, low-efficiency technologies continue to be used in large power systems, the disposal of waste heat may become a major environmental stumbling block.

Response

The effect heat ejection will have on the local areas remains to be seen. In the case of The Geysers, heat ejection or losses have not been a problem. Cooling towers are used and though they do raise the local humidity to some degree, it is not noticeable and no change in vegetation has been detected to date. There are, throughout the west, numerous areas where large amounts of water are evaporated into the atmosphere each year without any noticeable effect on the weather pattern.

In the San Joaquin Valley, where irrigation was introduced more than a century ago, several million acre-feet of water per year are evaporated into the atmosphere of this closed basin without noticeable adverse impact.

Comment Center for Law and Social Policy, I-249

The low efficiency of current geothermal power generation systems means that the resource is not being used with the conservation philosophy that we apply to other potentially depletable natural resources.

Response

Geothermal energy is presently a wasting resource through heat conduction to the atmosphere via natural water and steam discharges and heat convection.

Use of geothermal energy for electric power generation may result in low generating efficiencies under present technology. However, low energy conversion efficiency is not restricted to geothermal powerplants alone but is common to all thermal electric plants using nuclear or fossil fuels. Development of geothermal energy will result in useful return from this presently wasting resource. Improved energy conversion may be developed as more experience is gained through development of this energy source.

Comment Center for Law and Social Policy, I-192

The draft statement suffers from a lack of detailed information regarding the environmental problems posed by geothermal resource development, as well as the economic costs and possible economic or other benefits thereof.

Comment Environmental Protection Agency, I-64

Feel a cost analysis should be provided including cost and impact of alternative sources of energy production, fossil fuel, nuclear, etc. Adverse environmental effects are mentioned; however, there is no attempt to balance the costs of environmental degradation vs. benefits in terms of power and perhaps water produced.

Response

Additional information has been included for geothermal resources and energy alternatives in the final statement. With additional experience, it will be possible to make more detailed cost-benefit analyses and economic projections of the resource.

Comment Center for Law and Social Policy, I-192

What is the nature of the "data and information" expected to be obtained under the Department's leasing program?

Response

The "data and information" to be obtained under the leasing program include surficial geology, surface geophysics and subsurface information obtainable from drilling. Typical of the essential information needed to evaluate the resource in a given area are: subsurface temperature and pressures, fluid content, porosity, permeability, chemical character of fluids and areal and vertical extent of geothermal fluid reservoir. Without such data, which can only be obtained by extensive and expensive drilling, no accurate estimate of the resources is possible. Under the leasing program such activities would be carried out by private industry, at its own expense, in the expectation of the development of the resource at a profit. Such information would be available to the Government but would not be available to the public because of its proprietary nature.

Comment Center for Law and Social Policy, I-192

The Department appears to take the position that it is not necessary at this time to quantify potential environmental hazards but, rather, such information would be provided in connection with specific proposals for development.

Response

It is not possible to assess in detail the entire environmental impact of the program at this time as each individual location and its related geothermal fluids and gases may differ to various degrees. The program has been and will continue to be the subject of comprehensive evaluation and weighing of development versus impact. Environmental monitoring and evaluation will accompany all phases of resource development and use. Pertinent available information has been presented in this report. Additional details will not be available until the specific leasing areas are delineated.

Comment Center for Law and Social Policy, I-192

The generalized discussion of the potential environmental impacts in the three areas proposed for leasing in California demonstrates the Department's unwillingness to provide meaningful information as regards those specific sites (e.g., "throughout much of the developed areas of Imperial Valley, subsidence would cause costly damage...." E-31; see also C-28; C-31; C-36; D-20; D-23; D-26; D-30).

Response

The draft set forth all the pertinent specific information available. For example, the quote from p. E-31 concerning subsidence was followed by two pages of further explanation of the possibilities of land subsidence in Imperial Valley. Additional field evaluation has been conducted for the proposed lease areas, and the environmental statement for each has been expanded to provide more complete meaningful information.

Comment Center for Law and Social Policy, I-192

The Department has failed to describe in detail, or to make any attempt to quantify, the environmental harm or costs of controlling adverse environmental consequences of geothermal resource development.

Response

The final environmental statement contains more quantitative and specific data than contained in the draft environmental statement, but it should be borne clearly in mind that the magnitude of the effects are somewhat

speculative because of lack of production experience in the United States and high inherent variability of geologic and terrain characteristics by individual sites. The final statement presents all presently available pertinent detail and quantification; however, it is not possible to provide or predict additional detail and quantification with respect to the entire 700 million acres of public land subject to leasing. Sections II-B and II-D have been added to better describe the resource and the general environment of the western states. Specific areas, depending upon circumstances, may be the subject of separate environmental statements containing more detail and quantification if environmental evaluations indicate that impact statements are required.

Comment Center for Law and Social Policy, I-192

The draft statement provides no assurance that the many acknowledged environmental harms associated with geothermal resource development can be avoided.

Response

The draft statement does not pretend that all environmental harm can be avoided. Virtually any of man's uses of lands and resources have some form of adverse impact. Information presented in the statement does indicate that most impacts can be mitigated or minimized to environmentally acceptable levels. If this cannot be done, development will not be permitted. The discussion of mitigating measures has been expanded to better reflect this. The policy of the Department consistent with the law permitting private development as embodied in the regulations (Section 3204, 270.12) is to provide for controlled development in the public interest, minimize adverse environmental impacts, and limit or prohibit development where the environmental impact is deemed unacceptable.

Comment Center for Law and Social Policy, I-192

Neither the draft statement nor the proposed regulation is instructive as to how and by what standards environmental effects would be determined to be "unacceptable" by the Secretary in considering requests for use permits, or by other Department personnel charged with preventing environmental harm associated with lease operations.

Response

The specifics of standards have been detailed, insofar as practicable, in the new section, "Mitigating Measures," Vol. I, Ch. III, Sec. 3. What is unacceptable is a matter of both judgment and standards. While the Department does not pretend that geothermal development will have no environmental impact, the Department's policy remains that geothermal resource development on Federal land will be conducted in such a way as to minimize adverse impact to the acceptable limits as will be prescribed for each lease area.

Comment Center for Law and Social Policy, I-192

Environmental effects are portrayed for the most part on the assumption that they will be controlled, i.e., it is assumed that unavoidable effects can be mitigated and brought to acceptable levels (e.g., DS, 28). This approach is clearly wrong. The draft statement should first appraise in detail the raw impact of the proposed program without controls. It should then describe how this raw impact would be avoided or minimized and the degree of mitigation that can reasonably be expected from implementation of the proposed regulations.

Response

The program statement has been reorganized and expanded along the lines suggested. All presently available raw impact data has been set forth and possible effects and the effectiveness of mitigating measures have been estimated to the fullest extent possible at this time.

Comment Center for Law and Social Policy, I-192

Another serious defect in the draft statement is the failure to discuss in concrete terms the precise manner in which the proposed regulations and their implementation by the Department would provide the desired environmental protection which it is conceded will be required. Further, the draft statement contains no meaningful guidance as to the standards of environmental protection which the Department intends to utilize. Instead, it merely paraphrases the uninformative proposed regulations.

Response

The final statement contains a chapter on "Mitigating Measures Included in the Proposed Action," which sets forth and describes the environmentally protective regulations and standards, the manner in which they would be implemented, and the degree of protection they would reasonably be expected to achieve.

For example: the regulations provide that where applicable Federal or state standards exist, they shall apply to geothermal operations, specifically with respect to the use of poisons, and air and water quality standards (Section 3204.1(c)). Where applicable standards do not exist, it will be the field supervisor's responsibility to establish and enforce reasonable standards. When new State or Federal standards are established that should be applicable to any operation, the Department will apply them.

The degree of control of adverse impact reasonably expected with respect to fish and wildlife would be to limit impact so as not to seriously deny habitat to existing wildlife uses. Such control would be exercised mainly through regulation of the surface use of the Federal land as provided for in Subpart 3204.

It is envisioned that GRO Orders would be used to regulate matters common to many leases or to an entire producing district, whereas lease stipulations would be used to assure proper operation in matters applying to a specific lease. For example, a GRO Order might specify the acceptable noise at lease boundaries in The Geyser's field, whereas a lease stipulation would specify in detail the measures to be taken in constructing roads and sites to avoid excessive sediment runoff.

Comment Center for Law and Social Policy, I-192

The draft statement identifies a substantial number of potential environmental hazards, conceding that the information in the statement is of a broad nature and is intended to encompass generally the many potential environmental effects that could occur. The Department fails to explain satisfactorily why only broad information is given or to demonstrate convincingly that all available data and studies have been disclosed.

Response

Lack of specific information, where such is the case, is due to lack of development experience under conditions that would be applicable to the United States.

The final environmental statement has been expanded to further set forth all available information from the United States and much foreign information as well. In the final environmental statement, the chapter titled, "Mitigating Measures Included in the Proposed Action," further describes programs and studies designed to obtain more detailed information, including monitoring of geothermal development on Federal lands and means for alleviating unforeseeable problems that might arise.

Comment Department of Agriculture, I-7

The various listings of adverse impacts (as on pp. C-35 and C-36) should be expanded to include all of the possible unavoidable adverse impacts mentioned under "Environmental Impact of the Proposed Development."

Response

Only those impacts which cannot be avoided are included under III-D, "Adverse Impacts Which Cannot be Avoided Should the Proposal be Implemented," of the final statement. Mitigating measures for other impacts are covered either in III-C or by reference to the discussion elsewhere in the general statement.

Comment Gilmore and Gilmore, I-338

A copy of the Geothermal Steam Act should be included in the statement.

Response

A copy of the Geothermal Steam Act is included in Chapter 3, Section A of the final statement.

## B. PROGRAM ADMINISTRATION

Comment Center for Law and Social Policy, I-192

The proposed regulations delegate to the Director, Geological Survey, and supervisors in the field exclusive authority to establish standards for environmental harm and to approve pollution control programs. What consideration was given to providing for greater involvement of Federal, state and local authorities responsible for environmental protection in this process; why, for example, should not Federal Environmental Protection Agency have a veto power; what is the basis for relying to such a great extent on supervisors in the field; what qualifications, if any, will be required for supervisors?

Comment State of Colorado, I-89

We strenuously object to a USGS Supervisor who is not a professional wildlife man determining what measures are necessary to protect wildlife and wildlife habitat. Such determination should be made by the Bureau of Sport Fisheries and Wildlife in cooperation with State wildlife agencies.

Comment O'Rourke, John T., I-406

The geothermal law is weakened by allowing all controls and environmental decisions to be made by "the Supervisor".

Comment Pacific Gas and Electric Co., I-428

The power vested with Interior Department officials is so restrictive as to discourage geothermal resource development.

### Response

The Geothermal Steam Act of 1970 authorizes the Secretary of the Interior to make disposition of geothermal steam and associated geothermal resources. Section 24 of the Act directs that the Secretary shall prescribe such rules and regulations as he may deem appropriate to carry out the provisions of the Act. Sub-section (i) specifically identifies protection of water quality and other environmental values as one of the provisions. The Director, Bureau of Land Management, will have available to him the advice and assistance of all Federal agencies, including the Environmental Protection Agency, for evaluation of potential environmental impacts and for the development of necessary stipulations and environmental protection measures. Appropriate compliance with Federal, state and local government environmental laws, standards, etc., will be required.

The lead agency for environmental evaluation will be the Bureau of Land Management, since that agency is responsible for issuance of the leases.

Where public lands are administered by an agency other than BLM, such as the Forest Service in the Department of Agriculture, such agencies will be requested to make preleasing and leasing environmental investigations and recommendations relative to the proposed leasing. (See regulation Section 3200.0-6 for preleasing and lease procedures and Sections 3201.1-1 to 6 for Interior, Agriculture and other agency administered lands.)

Secretarial Order No. 2948, dated October 6, 1972, sets forth the division of responsibility between the Bureau of Land Management and Geological Survey for the administration and management of all departmental onshore mineral leasing and operating activities, including geothermal resources. (Additional detail has been included in Chapter I, Section E, pp. I-10 to 14 of the final impact statement.) Once a lease has been issued, only one agency must have direct responsibility for lease administration. The Geological Survey is the agency which has all of the broad expertise and capabilities required to assure proper development and production of geothermal resources. This includes activities such as geology, mapping, minerals, water resources, seismology, subsidence, monitoring, etc. It is recognized that the Supervisor may have limited capabilities relative to fish, wildlife or other land and resource values. Accordingly, he will make full use of the expertise of the land management agencies to help prevent or resolve any problems that may develop. These agencies will be directly involved in all actions leading to development of lease stipulations and operational orders. They will be called upon for assistance as needed. As a part of their multiple use management responsibilities, they will observe the impacts of geothermal operations and, should unacceptable impacts or actions be detected, they will so advise the supervisor so that necessary corrective actions will be taken. This affords a broad range of capabilities to assure adequate environmental protection. It also provides a check and balance mechanism for geothermal uses and their relationship to other land, natural resource and environmental values of the area. Maintaining such relationships through all stages of development and operation can avoid serious conflicts thereby facilitating the development of geothermal resources in an environmentally acceptable manner.

Comment      Center for Law and Social Policy, I-192

The proposed regulations authorize the Director, Bureau of Land Management, to evaluate and select tracts for leasing. In carrying out this function, he must, "when appropriate," evaluate the potential effect of the leasing program "on the total environment;" and, "when they are needed.....," develop special terms and conditions to protect the environment (3200.0-6). Unfortunately, the draft statement provides no guidance as to what factors will be weighed by the Director in exercising these broad powers. It merely paraphrases the relevant regulation (DS, 7-8). Moreover, no details are provided concerning future plans for selection of tracts for leasing or lease grants, including possible dates or areas under consideration.

## Response

The limitation "when appropriate" has been deleted from Section 3200.0-6 which now provides that "Prior to the final selection of tracts for leasing, the Director ... shall evaluate fully the potential effect of the leasing program on the total environment...." The regulations indicate the factors to be weighed. For example, Section 3200.0-6 provides for preparation of reports describing, to the extent known, resources contained within the general area and the potential effect of geothermal resource operations upon the resources of the area and its total environment. The section lists fish and other aquatic resources, wildlife habitat and populations, aesthetics, recreation, and other resources. Consideration also must be given to potential impacts on lands other than those included in a lease. Plans for leasing are generally set forth in the regulations. Noncompetitive leasing, applying to lands outside KGRAs, will be by application of the interested parties according to Part 3210. Such applications may be on any lands eligible for leasing outside KGRAs. Competitive lease tracts (in KGRAs) will be designated as stated in Part 3220 either by nomination on the motion of the authorized officer or by nominations by interested parties. Section 3220.3 provides for public notice prior to leasing. It is expected that the initial sale primarily will be of "grandfather" lands within one of the three proposed lease areas.

Comment      Center for Law and Social Policy, I-192

The proposed regulations authorize supervisors to suspend lease operations on their own motion "in the interest of conservation." The draft statement fails to indicate whether the Department considered permitting suspension when necessary to prevent adverse environmental effects, as well as permitting persons affected by such operations to seek such relief and, if so, why was this approach rejected?

## Response

Section 270.80 provides for termination of the lease after due notice in case of failure to comply with lease terms and regulations. Section 270.12 gives the Supervisor specific authority to issue orders requiring, among other things, the protection of environmental quality. Failure to comply with such orders can result in immediate suspension of operations. There is no basis in the geothermal law for permitting persons not party to the lease to suspend lease operations. However, persons who feel they are suffering damage may seek relief under provisions of other laws.

Comment      Center for Law and Social Policy, I-192

The proposed regulations authorize supervisors to issue Geothermal Resource Operational Orders to, inter alia, protect against environmental harm from lease operations. The draft statement does not explain the reasons for adopting this regulatory scheme or indicate whether the Department considered the establishment of minimum performance standards with respect to identifiable environmental problems to govern all lease operations regardless of location and, if so, why this approach was rejected?

## Response

The policy of using GRO Orders follows the procedures applied successfully in management of production of other leasable minerals. This provides operating flexibility needed for reasonable site sensitive resource management tailored to each specific situation. Because of the wide variability of terrain, geology and land use on the lands subject to leasing, "minimum performance standards for environmental problems" in many matters would be so generalized that they would not be meaningful. For example, a well or wells in a remote desert area may have little, if any, real impact on environmental conditions. By contrast, development in areas of higher rainfall, steep topography, dense vegetation, significant wildlife population, heavy public use, etc., would require entirely different provisions. The regulations prescribe use of minimum standards where such standards exist on a nationwide basis, i.e., Federal and State Water and Air Quality Standards (see for example Sections 3204.1 and 270.41).

Comment Duke University, I-279

If initial test wells are to be drilled on Federal lands they should be done under the supervision of the United States Geological Survey.

## Response

All geothermal activity on Federal lands, including drilling of test wells, is supervised by the Geological Survey as provided in the operating regulations, Sections 270.14 and 15.

Comment Oregon Environmental Council, I-688

The issuance of GRO standards for erosion control, noise control, waste disposal, wildlife protection and others on a site-by-site basis could result in cases of permissive standards.

## Response

All operations will be governed by the regulations. The purpose of lease stipulations or GRO Orders is, among other things, to provide adequate control over potential hazards or impacts which may be peculiar to a particular lease or area. GRO Orders are subject to the approval of the Director of the Geological Survey and are therefore not "permissive" on the part of a particular supervisor even if he were prone to be so. The land management agency responsible for overall administration of the public lands and resources involved will provide assistance as needed and will observe lease activities and if unacceptable adverse impacts are detected, will recommend necessary corrective actions.

Comment Pacific Gas and Electric Company, I-626

Duplication of existing adequate Federal regulatory controls should be eliminated from the statement.

## Response

There is some unavoidable overlapping or duplication in various regulatory controls. This is considered to be necessary to provide specific regulations governing each phase of geothermal operations.

Comment Center for Law and Social Policy, I-192, I-249

The draft statement contains no plans for implementing the geothermal resource development program in terms of either areas to be affected, or schedule of selection proceedings, or lease grants.

## Response

The final Environmental Statement sets forth the leasing proposed for the three areas in California. Specific implementation plans are not practical at this time as interest in development of various areas cannot be predicted. Upon receipt of applications, further leasing plans will be developed. Section 3210.1 provides that lands and deposits subject to disposition under this part which are not within any KGRA will be available for leasing upon application after the effective date of those regulations. Section 3220.1 provides that lands within a KGRA, except as provided under Section 3201.1, will be available for leasing on the effective date of those regulations. The authorized officer will accept nominations to lease, or may on his own motion from time to time call for nominations to lease. Section 3200 sets forth a description of lands available for leasing. Section 3200.0-6 sets forth the preleasing procedures, including environmental evaluations and environmental impact statements. If such evaluations indicate that geothermal resources cannot be developed within acceptable environmental limits, no lease will be issued.

## C. ENVIRONMENTAL STATEMENTS

Comment Environmental Protection Agency, I-64, I-74; Duke University, I-279; Lake County Geothermal Control Council, I-367; Oregon Environmental Council, I-686; Sierra Club, I-436, I-702; and Washington Environmental Council, I-545

Each lease should be covered by a separate environmental impact statement, and public hearings should be held for each lease area.

Comment Sierra Club, I-436

Environmental impact statements should be required from all applicants for geothermal leases and should be made available to the public.

### Response

Environmental statements for each of the three geothermal areas on which preliminary leasing is contemplated have been prepared and included as Volume II of this document. These statements detail, to the extent known, possible environmental impacts, alternatives and mitigating measures for such impacts. As additional areas are considered for leasing, environmental evaluations will be prepared as required under Section 3200.0-6 of the leasing regulations and, where necessary, environmental statements will be prepared according to Section 102(2)(c) of the National Environmental Policy Act of 1969. Public hearings may be held to assist in informing and soliciting the opinion of the public concerning areas proposed for leasing.

Comment Center for Law and Social Policy, I-192

The Department should expressly undertake to prepare and file environmental impact statements in connection with consideration of lease requests, as well as the selection of tracts for leasing and surface use permits. At the least, the Department should adopt a procedure whereby, if it determines that a particular action taken does not warrant an impact statement, it would promptly make its decision available to the public, together with a detailed statement of the reasons underlying it.

### Response

The Department will prepare environmental evaluations for each area proposed for leasing. Environmental impact statements will be prepared for proposed individual leases if the issuance of such a lease would itself constitute a major Federal action significantly affecting the quality of the human environment which has not previously been evaluated in an environmental statement. This is explained in greater detail in Volume I, Chapter 1, of the final impact statement.

Any requirements of impact studies for stages of development subsequent to the area environmental impact statement would be a deterrent to development. The general environmental impact statement should provide for clear authority to proceed with development.

Response

Although the general environmental impact statement would cover the overall possible environmental impact, it may be necessary to have separate impact statements for specific leases within the area. Implicit in the issuance of a lease is the recognition that the lessee is entitled to use as much of the surface land covered by his geothermal lease as may be determined by the Secretary to be necessary for the production, utilization and conservation of geothermal resources. (See P.L. 91-581, Section 14.) A separate permit is necessary prior to plant construction and development because in most circumstances the size, type and exact location of construction cannot be determined until the exploration phase is completed. Aspects such as the nature of the resource, the geologic and biologic setting and the physical properties of the geothermal fluids may impose environmental factors not evident or adequately considered in the pre-development environmental evaluation. In such instances, appropriate evaluation must be made before proceeding to operational development. In many instances, the initial evaluation may prove to be adequate. In other instances, additional environmental protective measures may have to be considered.

Comment Center for Law and Social Policy, I-192

The only information relating to environmental harm required in applications for leases is "a narrative statement" describing proposed pollution control measures. Did the Department consider requiring preparation of a detailed environmental impact report, including evaluation of alternatives and reasons for rejection of them and, if so, why was this alternative rejected?

Response

Requiring an environmental impact report from each bidder prior to leasing would be impractical. Until his bid has been accepted, a prospective bidder would not be in a position to prepare a meaningful evaluation and would probably be unwilling to bear such a cost at that time. Also, requiring numerous prospective bidders to prepare environmental reports for the same tracts would be redundant, especially when it is considered that the BLM already will have conducted an environmental evaluation pursuant to Section 3200.0-6 and, where necessary, have already prepared a formal environmental statement.

With respect to noncompetitive leasing, Section 3210.2-1(d) requires of the applicant a statement describing planned measures to prevent or control fire,



#### D. SEPARATE PERMIT REQUIREMENTS

Comment Geological Survey, I-47; State of California, I-81; Geothermal Resources International, I-640; Getty Oil Company, I-618; Signal Oil and Gas Company, I-461; Pacific Gas and Electric Company, I-408, I-410, I-626; Union Oil Company, I-522, I-526, I-557

The issuance of Federal geothermal leases should include provision for power plant and transmission line construction without the requirement of a separate permit. Such a permit requirement is a hindrance to the producer and may result in a denial to produce power after a geothermal field has been proven.

#### Response

The permit requirements for a powerplant and transmission lines are necessary to insure proper siting, design and construction techniques with minimum environmental impact. Since such facilities cannot be planned until a geothermal field is proven, a permit for construction will assure that adequate planning for land, resource, and environmental impacts are taken into consideration. The leasing regulations require that prior to the final selection of lease tracts, the Director of the Bureau of Land Management or agency head charged with administration of the surface will conduct an environmental evaluation which, among other things, will consider the potential impact of power generating plants and transmission facilities on lands not included in a geothermal lease. Permits will not be issued unless the facilities can be built and operated in an environmentally acceptable manner. To the extent possible, all factors will be included in the prelease evaluation, but further evaluation is necessary as specific resource information becomes available for use in planning production development. (See Volume I, Chapter III, Section C, of the final impact statement for additional detail.)

Comment Center for Law and Social Policy, I-192

The draft statement indicates that the requirement for surface use permits may be nothing more than a formalistic procedure, to rubber stamp commitments made (or, at least understood) at the time leases are granted. The Department appears to have adopted the procedure utilized under the Mineral Leasing Act whereby, once a prospecting permit to explore for minerals is issued, the grant of a development lease is viewed as automatic by the Department (assuming discovery of valuable minerals). We strenuously object to this approach--which is not sanctioned by the Geothermal Steam Act of 1970--and recommend that the Department prepare and include in any final regulations detailed standards to govern issuance of use permits which, at a minimum, require findings by the Secretary prior to issuance of a use permit that: there is a clear need for the power or by-product involved; the proposed use would not result in significant adverse environmental effects; and, less harmful alternatives are unavailable.

## Response

The provisions of the regulations with respect to surface use permits are in accord with the Geothermal Steam Act, Section 14, which provides that a lessee shall be entitled to use so much of the surface of his lease as may be determined by the Supervisor as necessary for the production, utilization and conservation of geothermal resources.

The provisions requiring a separate permit for the use of the surface for an industrial facility is intended as a further safeguard against environmental damage. It assures the Department of a review and opportunity to modify or, if necessary, disapprove plans after the resource has been partly assessed, but before very large financial commitments have been made if development and production cannot be conducted in an environmentally acceptable manner. Contrary to the reviewer's assumption, this is not a rubber stamp procedure, rather it provides an opportunity to impose necessary additional stipulations in the interest of environmental protection which would be applicable to the development phase of the resource.

Detailed standards for permits would not be generally practicable as each site may present problems peculiar to that geographic, geologic or resource setting. Many surface uses will require site sensitive permits such as for well sites, access roads, location of power poles and clearing of brush under power lines which could not be adequately covered by general standards.

All potential environmental problems posed by proposed developments must be considered in deciding whether or not to grant the required surface use permits. However, the law does not authorize the Secretary, through the media of the power plant use permit, to control the development of electric power or the byproducts involved. These matters generally are for the judgment and decision of the private developer, subject to applicable Federal, State, and local government laws and regulations.

## E. PUBLIC PARTICIPATION IN DEVELOPMENTS CONCERNING GEOTHERMAL POWER

Comment Center for Law and Social Policy, I-192; Lake County Geothermal Control Council, I-367

Public hearings should be conducted at several stages in the development process, including a hearing for the consideration of all applications for leases.

Comment Oregon Environmental Council, I-686

Requests mandatory public hearings prior to approval of any unitization.

Comment Lake County Geothermal Control Council, I-367; Sierra Club, I-436, I-702

Provision should be made in regulations for mandatory public hearings in case of public complaint arising from violations which adversely affect the local environment or the public welfare.

Comment Center for Law and Social Policy, I-192

The proposed regulations fail to require public hearings for land selection, lease grants, and the grant of surface use permits. What was the basis for selecting this approach as opposed to a mandatory hearing requirement? As regards permits for power plants, the Secretary is granted blanket authority (without any standards) to approve such facilities. Why are environmental authorities and local representatives not explicitly included in the decision making process? What alternatives were considered?

### Response

Section 3200.0-6 provides that the Director, Bureau of Land Management may hold public hearings prior to selection of tracts for leasing. This was not made mandatory because in many situations a hearing might serve no useful purpose. Information concerning proposed leasing actions will be made available to the public. Where there is a need to further inform the public or to solicit public opinion, public hearings will be held. As regards power plants, Section 3200.0-8 requires a separate permit prior to construction of industrial facilities, including powerplants. Proposals to issue power plant surface use permits would, where major considerations are involved that have not been previously described in the impact statement, require the preparation of an environmental impact statement. In such cases adequate opportunity would be provided for interested parties to participate in the decision making process.

## F. APPLICATION OF STATE AND LOCAL LAWS

Comment City of Los Angeles, I-132

Regulations should provide for recognition of local agency regulations by calling for local review of water-treatment facility plans proposed for geothermal operations on Federal leases.

Comment State of California, I-78, I-81, I-648; Imperial County, California, I-634; Lake County Geothermal Control Council, I-367; Sierra Club, I-436, I-707

Standards and regulations set by local, county, regional or State entities should be applied to Federal lands for the control of air and water quality, noise, erosion, waste storage and disposal, road cuts, banks, and dikes.

Comment Lake County Geothermal Council, I-367

Casing standards and drilling precautions should meet minimum requirements no less strict than State and local standards.

Comment State of Nevada, I-104, I-105, I-580

Compliance with State water laws should be mandatory for geothermal operations on Federal lands since these operations consume water.

Comment State of Oregon, I-121, I-675

State regulations in Oregon provide the necessary protection of the environment from the drilling of geothermal wells. Regulations should make a State water law mandatory in geothermal operations.

### Response

State laws and regulations are applicable to Federal lands only to the extent that the United States laws authorize such application and they are consistent therewith. Local governments are subdivisions of the State and, therefore, laws issued by local governments pursuant to the laws of a State are in most cases State laws. Accordingly, the laws of some local governments, like laws enacted by State governments, may be recognized as being applicable to some Federal lands but not to Federal operations as such.

Where State laws and regulations exist and can be directly applied to the proposed geothermal leases to assure adequate environmental protection, such standards have been incorporated into the leasing and operating regulations. For example, Sections 3204.1(c)(2) and 270.41 require lessees to conduct all operations in compliance with Federal and State standards with respect to the control of all forms of air, land, water and noise pollution. The Supervisor may establish more stringent standards if necessary. Sections 3204.1(c)(3) and 270.41 similarly require lessees to comply with Federal and State pollution control standards.

County standards may be adopted as lease stipulations for geothermal leases on Federal lands within each county. In addition, the Supervisor may issue Geothermal Resource Operational Orders which incorporate all or portions of other State or local regulations where such adoption is deemed desirable on Federal lands. GRO Orders will be enforced by the Supervisor rather than by local regulatory agencies. (For additional details, see Volume I, Section III-C of the final environmental impact statement.)

## G. TEST PROGRAM

Comment Department of Agriculture, I-7, I-15; Washington Environmental Council, I-545

Urge consideration of a test program to obtain more information on environmental effects prior to leasing.

Comment Oregon Environmental Council, I-402

Objects that alternatives contain no provision for a pilot project.

Comment Oregon Environmental Council, I-686; Sierra Club, I-710

Only a limited number of pilot projects leases should be issued where environmental impact is expected to be at a minimum.

### Response

This subject is discussed under the alternatives section in Volume I, Chapter IV of the impact statement. A test program is, in effect, being developed through potential leasing of Federal lands in The Geysers, Mono Lake-Long Valley and the Imperial Valley areas. Built-in time delays plus the discretionary authority of the Secretary of the Interior or his delegate to lease or not to lease other lands for geothermal development will allow time for the initial test drilling and development at these sites to be evaluated regarding resource potentials and environmental impacts. It is anticipated that a large number of non-productive wells will be drilled during any geothermal exploration program. These wells, such as the Deep Geothermal Test Well Facility in the Imperial Valley, provide useful geological data but provide little information on environmental impact.

Due to wide variations of physical features and land usage around the many potential geothermal areas, it is considered desirable to allow exploration and development on a number of leases in several areas so that useful information can be generated on potential environmental impacts of the geothermal leasing program and resultant operations.

Comment Center for Law and Social Policy, I-192

The draft statement asserts that "significant areas exist in other parts of the country," but does not state where such areas are located, why they are deemed significant, or the Department's plans for developing them.

### Response

Additional discussion relative to the resource and the related environmental setting has been included in the final impact statement (Volume I, Chapter II-A, B and C). "...significant areas--in other parts of the

country" refers to extensive public domain and acquired lands subject to leasing under the Geothermal Steam Act in the states where no lands have been classified as KGRAs. Although these lands are not considered to have a great potential for geothermal resource development, one who thinks he can develop geothermal resources thereon, has the option of nominating eligible lands under the noncompetitive leasing provisions of the Act, and the application must be given consideration by the Department. The factors considered in classifying lands are described in Appendix H and Regulation 3200.0-5.

Comment Center for Law and Social Policy, I-192, I-257

The Department must provide a detailed description of its plan to carry out the development program, including its priorities in terms of land selection and use, and schedules for land selection and lease sales.

Response

The Department's program is to lease Federally-owned resources under the provisions of the Geothermal Steam Act. Schedules for land selection and lease sales will depend largely upon nominations of lands by individuals under the terms of the Act. It is expected that most interest initially will be shown in the three areas in California described in Volume II of the statement because economic prospects for development appear to be the most favorable at these locations. Elsewhere, the Department plans to await nomination pursuant to Section 4 of the Act. Where environmental evaluation indicates that leasing would constitute a major Federal action significantly affecting the quality of the human environment, an environmental statement will be prepared in accordance with NEPA.

Comment Center for Law and Social Policy, I-192

Nothing in the draft statement persuasively shows that (for example) a two-to-five-year postponement in the full implementation of the program would result in significant environmental costs, or critical shortages of electric power, mineral products or fresh water.

Response

Discussion of the effects of delaying leasing action has been included in the alternatives section of the final impact statement (Volume I, Chapter IV). Postponement of development, particularly in areas such as southern California where alternative energy sources will have to be developed in lieu of potential geothermal electrical energy production, could result in actions or commitments that could be more environmentally damaging than development of geothermal resources. The discussion of electrical energy alternatives in the impact statement has been expanded to provide a better basis for evaluation of such alternatives. While there probably would be

no serious consequences from a delay of from three to five years, there seems to be little reason for such delay in view of the exploration and development work already done or underway on private lands and in the areas proposed for leasing. The sooner the exploration and development work is done on Federal lands, the sooner the resource potential and the site-sensitive potential adverse impacts can be determined. Geothermal resources have the potential of being an environmentally superior energy source provided adequate knowledge and experience are obtained. Provision has been made for environmental evaluation and protection for each phase of exploration, development, and production. Where such activities can be done in an environmentally acceptable manner, it would facilitate development of needed information and technology for use of resource potentials in other areas.

Response

## H. BONDING

Comment Lake County Geothermal Control Council, I-367; Sierra Club, I-436, I-706

Bonding of considerably higher amounts is needed than that set forth in Sections 3104.9 and 3206.1-1 of the leasing regulations for the protection of person and property.

Comment Center for Law and Social Policy, I-192

Bonding requirements as set forth (Sections 3045.3-1 and 3206.1-1) are intended to provide adequate compensation for potential environmental damage. The draft statement, however, contains no discussion of the reasons for selecting the proposed amounts or what alternative amounts were considered and why they were rejected.

### Response

The bonding requirements of Section 3045.3-1 have been revised to provide that a surety bond in the amount of not less than \$5,000 shall be required. If factors warrant, a higher bond can be required consistent with the potential for remedial action costs or other public damages. Each case will have to be considered on the basis of the anticipated exploration or development impacts. Similar bonding requirements relative to other mineral leasing actions have proven to be effective in adequately protecting the public interest.

## I. LAND USE

Comment Department of Agriculture, I-7; Environmental Protection Agency, I-64; State of Oregon, I-675; Oregon Environmental Council, I-691

Environmental impact statement should consider multiple uses for land.

Comment State of California, I-81

Environmental impact statement fails to point out the conflict that geothermal development would have on other land use, as with prime agricultural land in Imperial County and resort development at The Geysers.

Comment Western Rockhound Association, Inc., I-550

The organization believes regulation 3200.08(b) should be more directly stated to permit the non-commercial recreational use of geothermal lands to the extent possible.

Comment Center for Law and Social Policy, I-192; Lake County Geothermal Control Council, I-653; Sierra Club, I-702

Regional effects of geothermal development such as air, visual and noise pollution are not considered in terms of recreational or residential character of some areas.

Comment State of Colorado, I-89

The recreational, aesthetic and therapeutic benefits which could be derived from geothermal resources on public lands were ignored in this report. Provisions should be made for development or protection of these values.

### Response

The environmental setting has been more fully developed. The sections on environmental impacts and mitigating measures of the final environmental statement have been expanded and revised to more fully assess the potential impacts and feasible mitigation of those impacts. Section 3200.0-6(b) of the leasing regulations requires that the Director, or head of agency charged with administration of the surface, shall evaluate fully the potential effects of the leasing program on the total environment, aquatic resources, aesthetics, recreation, and other resources in the entire area. Section 270.11 and Section 270.15(f) of the leasing regulations provide that geothermal activities must not interfere with the multiple use of lands. Section 3200.0-8(b) authorizes the continuation of permitted uses on public lands. Any specific effect on the environment which is not covered by the regulations can be covered in lease stipulations or by GRO Orders.

Comment Department of Agriculture, I-7

Clear Lake - Geysers Area: the control of the surface effects of grading and road building is not adequately covered (pp. C-12,13). Temporary structural measures may be necessary to control landslides and sediment on some sites.

Comment Department of Agriculture, I-7

Mono Lake - Long Valley Area: it does not appear that adequate provision is made for sediment control on roads and well sites (p. D-11). Gentle slopes and an arid climate do not assure low rates of erosion and sediment discharge. The sediment control requirements of the proposed regulations mentioned on page D-12 apparently refer to Sections 3204.1(c)(4) and 270.41 of Appendices A and B. Those sections do not appear to be very specific.

Comment Department of Agriculture, I-7

Imperial Valley Area: erosion and sedimentation from the sites in this area do not appear to be significant.

Comment State of California, I-81

Potential severity of sediment runoff in Mono Lake - Long Valley area is exaggerated.

Response

Expanded discussion for sediment and erosion control has been included under "Mitigating Measures Included in the Proposed Action" in both the regulation section (Volume I) and for all three of the areas (Volume II). Section 270.41 of the regulations has been modified to include provisions for erosion control according to Federal or State standards.

## J. GEOLOGY

Comment State of California, I-81.

The general statement and the three geographical areas should contain a more detailed discussion of geology including subsidence as it relates to the geothermal phenomena.

Response

A more detailed discussion of subsidence and earthquake activity is included in the general statement. A discussion of the two types of geothermal systems, vapor-dominated and liquid-dominated systems, is included as Appendix G. Detailed discussions of the known geology, including seismicity, subsidence and the geothermal system for the three geographical areas are included in the respective area statements in Volume II.

Comment State of Oregon, I-121.

All geologic information from geothermal developments on Federal lease should be made available to the affected states.

Response

The major portion of the geologic and engineering data acquired by the Geological Survey during the course of supervising operations on Federal lands is supplied by the operator. Much of this information is considered to be proprietary data and it cannot be made available to the public until the lease expires without the consent of the lessee as specified in Section 270.77 of the operating regulations. Therefore, in order for a state to obtain such data from Geological Survey files, it must have the written permission of the lessee or operator.

Comment Pacific Gas and Electric Company, I-410.

Suggest word changes for p. C-23 of the draft statement relating to landslide hazards.

Response

Much of the suggested wording has been incorporated into the final statement for the Clear Lake - Geysers area statement.

Comment Environmental Protection Agency, I-60.

Reinjection of waste fluids, if employed, must guard against contamination but, in addition, must consider the possibilities of including seismic activity and damaging rare dry steam resources.

Comment State of California, I-81; Getty Oil Company, I-618;  
Southern California Edison Company, I-598

The statement should emphasize in more detail the tectonic setting of geothermal areas. Operators should not be held liable for naturally occurring seismicity. The danger of microearthquakes induced by fluid injection has been overemphasized in the draft impact statement. The responsibility for seismic monitoring should be assigned to the Federal government. Remedial actions to alleviate seismicity should be defined in the impact statement.

Comment State of Montana, I-103

More research in the area of seismicity is necessary before conclusions may be drawn.

Comment State of California, I-648

The hazards of earthquakes associated with geothermal development has been overemphasized in the draft environmental statement.

Comment Environmental Protection Agency, I-64

Not mentioned is the possibility of a significant decrease in the normal natural seismic activity of an area. This may indicate a locking of an active fault which would permit a built-up of greater stress before movement occurs. Hence dewatering active faults may result in a lessening of seismic frequency but an increase in magnitude of severity when earthquakes do occur.

Comment Dunn, Franklin, I-285

The environmental statement for the Mono Basin does not mention the possibility of oblique drilling intersecting faults and the consequences of fault movement on well integrity nor are corrective or preventive measures discussed.

#### Response

The section on seismicity in the final impact statement has been revised to present in more detail the tectonic setting of geothermal areas, their past earthquake history and measures which may be taken to mitigate induced seismicity. The discussion of natural vs. induced seismicity has been changed to clarify the fact that all seismicity associated with fluid pressure changes to date has been of small magnitude and has occurred only near the points of injection. Most seismologists believe that changes in fluid pressure in regions of natural tectonic stress only vary the normal pattern or timing of release of strain by earthquakes. Fault movement associated with induced earthquakes would have the potential of cutting well casings and surface or near-surface pipelines with the result of fluid loss

at the surface or into near-surface aquifers. The related risk at specific sites would be related to the natural accumulated strain along existing faults in the area of injection. In many cases these faults may not be known until after movement has occurred, as was the case of the Derby fault at the Rocky Mountain Arsenal Well near Denver, Colorado.

The Department of the Interior feels that regional monitoring of seismicity should be the responsibility of the Federal government and has agreed to accept this responsibility. The existing regional network of seismic stations operated in southern California is not sufficient to accurately locate the earthquake epicenters in the Imperial Valley and several new stations will be needed in the area to pinpoint earthquake source with respect to geothermal development. Plans to establish these stations are being made in cooperation with the California Institute of Technology, which operates the existing network of strong motion instruments in southern California. If correlations of the monitoring program indicate that damaging seismic activity may be attributable to geothermal development or reinjection of brines, that particular facility will be shut down until remedial actions can be initiated. Remedial actions would include lowering of injection pressure or limiting production rates to safe withdrawal levels.

Comment      Center for Law and Social Policy, I-192

Perhaps the most glaring example of the Department's failure to explain contemplated environmental controls relates to risks of increased seismicity and subsidence as a result of altering reservoir pressure, which are major environmental concerns.

At page 39 of the draft statement, it is suggested that, in the event of increased signs of seismic activity, operating and production procedures would be modified. We are not told, however, how or precisely when these procedures would be modified and to what extent such modification is likely to stem the damage.

Response

Increased seismicity and major land subsidence are not generally experienced in other mineral operations, and measures to control these phenomena where they are significant are not standard practice, and therefore, are not amendable to standard operating procedures. Either, neither, or both phenomena may or may not be significant in a given producing area. In geothermal development in other countries, these phenomena have not been a serious operating problem; however, these foreign developments do not have, for example, the unique features of Imperial Valley, where a maximum earthquake hazard is combined with maximum potential for land subsidence. References cited in the statement describe how analagous operations in oil fields and elsewhere have led to increased seismicity and subsidence. This does not mean that geothermal development will inevitably lead to the same problems; however, since the possibility exists, it is discussed in

more detail in the final environmental statement.

If monitoring indicates significant increase in seismicity associated with geothermal production, the Supervisor may limit production or require other actions to reduce seismicity (Section 270.43) of the operating regulations. Similarly, if reinjection produces a significant increase in seismic hazard, the Supervisor may limit injection pressures to reduce the effect. As experience in these aspects of geothermal operations is negligible, reliance must be placed on remedial measures used in analogous operations, such as oil production and repressuring, but with sufficient operating flexibility to permit prompt and responsible decisions at field level. Land subsidence is a function of the hydrology and geology of the producing zone and can only be determined by observation during production. If this proves a significant problem, it can be ameliorated by reservoir-pressure control, either through limiting production or by reinjection, as has been successfully practiced elsewhere in California where production of petroleum or water has resulted in subsidence.

Comment

Dunn, Franklin, I-285

The use of heat rising from the interior of the earth for generation of electric power is a relatively recent and scattered development. Experience at these plants has been largely anecdotal, and little is known of the potentially enormous effects that the accelerated withdrawal of the earth's heat may have. It has been speculated that such withdrawals might influence the pattern of turbulence in the earth's core, a pattern which is believed to be responsible for the magnetic field orientation. A small shift in this pattern could lead to the statistically overdue magnetic reversal of the earth's north- and south-poles. Such a period of shift to the opposite magnetic polarity might last thousands of years, during which time the protective van Allen radiation-deflecting belts would weaken, and the earth's unprotected surface would be bombarded with deadly high-energy particles and energy from space. Such apocalyptic speculation is clearly alarmist; however, it should give some caution to those who see exploitation of geothermal heat as a simple and immediate "solution" to our energy crises. It is interesting to note that power company experts I have talked to had never heard of this concept.

Response

Exploitation of geothermal energy is neither a simple nor immediate solution to the energy crises. Under optimal conditions, geothermal energy will amount to only a small fraction of total energy output. Extraction of heat for geothermal energy production will tap only that heat which has already been lost from the center core to the outer crust. Such heat is normally dissipated to the atmosphere through geologic processes such as volcanic and various thermal phenomena. There is no present or foreseeable technology for penetrating or effecting a loss of center core heat resulting in the problems mentioned in the comment.

## K. SUBSIDENCE

Comment California State Resources Agency, I-81

A subsidence hazard is not demonstrated at The Geysers, nor can it be attributed to production at Cerro Prieto.

Comment Pacific Gas and Electric Company, I-410; Union Oil Company, I-522

Subsidence depends more on the underlying rock types; (PG&E recommends that a phrase be inserted in the impact statement text indicating that subsidence is not a demonstrated problem at The Geysers).

Comment Center for Law and Social Policy, I-249

Recommend regulation requiring operators of geothermal projects to cooperate in subsidence . . . monitoring programs.

Comment O'Rourke, John T. M., I-406

A network of benchmarks should be established and checked yearly for detection of any ground movement.

Comment Getty Oil Company, I-618

The responsibility of subsidence monitoring should not be on the operator but on the Federal Government.

Comment State of California, I-648; American Thermal Resources, Inc., I-162; Getty Oil Company, I-618; Southern California Edison Company, I-591

Statement should emphasize in more detail the tectonic setting of geothermal areas. Much subsidence could be naturally occurring due to dynamic crustal processes.

Comment Environmental Protection Agency, I-64

Discussion of subsidence in the Imperial Valley trough by Geothermal development in both U.S. and Mexican sections do not mention the possibility of lowering the area between the Sea of Cortez (Gulf of California) and the Salton Sea. Long term and continuous subsidence control may be needed if there is a possibility of the reconnection of the Sea of Cortez section of the trough if below sea level.

### Response

The final environmental statement has been revised to stress that subsidence will vary according to the characteristic of the underlying rocks and may be acceptable within limits, in some areas. A statement on the tectonic setting of geothermal areas has been

included in the general and area statements. A grid of level lines to monitor subsidence is being established in the Imperial Valley and at The Geysers, as will be done in any geothermal lease area. Although subsidence has not been demonstrated at The Geysers area, it is suspected because the Coast Range consists of incompetent formations that are subject to physical change. In addition, The Geysers field has been sustaining its reservoir pressure surprisingly well, which tends to indicate that subsidence may be occurring.

Comment State of California, I-81

It should be clarified that up to 19 feet of horizontal displacement occurred at only one place on the surface during the 1940 El Centro earthquake in Imperial Valley.

Response

Wording of the final statement has been modified to reflect that this was the maximum surface displacement.

## L. NUCLEAR STIMULATION

Comment Center for Law and Social Policy, I-192

The Department has inexplicably chosen to omit from the draft statement any discussion of the problems posed by or the prospects for the use of nuclear explosives to augment geothermal resources.

Comment Finn, Donald F.X., I-319

The statement should cover the impact of nuclear explosives on the environment when used to supply an underground heat source in connection with geothermal development.

### Response

Discussion of the potential environmental effects of the use of nuclear explosives for natural gas stimulation has been included in the discussion of alternatives in Volume I. No proposal for similar geothermal development is being actively considered. Any proposal to use nuclear explosives would be under a permit from the Atomic Energy Commission, and the potential impacts of such an action would have to be covered by an environmental statement as required by NEPA. The Department could bar the use of such devices on Federal leases within the discretionary authority under Subpart 3200 of the leasing regulations.

No detailed studies of the feasibility of nuclear fracturing in connection with geothermal development have been made. The Atomic Energy Commission is on record 1/ to the effect that use of nuclear explosives in geothermal development is not currently under study, and no funds are authorized for such studies.

Unless and until scientific studies show that nuclear fracturing would be technically and economically feasible in geothermal development and procedures for nuclear stimulation are developed, the environmental impact of such nuclear programs cannot be effectively appraised. Accordingly, the use of nuclear explosives is not for consideration within this environmental impact statement and the related regulations.

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1/ Statements by A. Ewing, Atomic Energy Commission, Proceedings of Seminar on Geothermal Energy and the Environment, United Nations, New York, May 22, 1972, pp. 94-95 and 96-97.

M. WATER AND BRINES

Comment Environmental Protection Agency, I-60

Should reinjection disturb equilibrium of the reservoir, it could damage the dry steam field.

Comment Pacific Gas and Electric Company, I-410

The environmental impact statement overstates impact of reinjection on lakes and drainages. Recommends that the phrase "Reinjection of waste geothermal fluids into a geothermal reservoir shall be permitted under controlled conditions" be added at the end of paragraph 3204.1(c)(2).

Comment Southern California Edison Company, I-470

Because geothermal brines may be compatible with the underground reservoir, the lessee should have the right to reinject any unused portion of the geothermal effluent into any formation that does not contain potable water (ref. Section 3204.1(c)(2), water pollution regulation).

Comment Union Oil Company, I-529

We firmly believe that injection schemes can be designed so as to protect near-surface and surface waters (and that) the threat of pollution through reinjection is minimal.

Comment Department of Agriculture, I-7

No mention is made of soil pollution by disposal of geothermal brines into streams. Also express concern of polluting the soil with heavy metals.

Comment Getty Oil Company, I-618

Existing local, State, and Federal controls are adequate to prohibit discharge of toxic substances into streams or into fresh water aquifers.

Comment State of California, I-81

The construction of reinjection facilities will have some impact on the surface environment but should not be considered as a decided change in land use.

Response

Investigation of hydrodynamic characteristics of the subsurface strata must be explored prior to reinjection of geothermal wastes. Generally,

it is assumed that the spent brine would be returned to the same general horizon of the geothermal reservoir as the feed water to lessen the possibility of local subsidence and to reduce the threat of geothermal effluent contamination to ground and surface potable water supplies. Additional study would be required within specific geothermal areas to determine if reinjection of geothermal effluent can be permitted in strata other than the zone from which it was produced.

Expanded discussion relating to waste water reinjection is covered under the heading Field Development found in Volume I, Chapter III, Environmental Impact of the Proposed Action. The final environmental statement has been expanded to more fully discuss water pollution control standards. This information also covers the problem of potential soil pollution by disposal of geothermal brines and heavy metals.

Comment State of California, I-81; State of Colorado, I-89; State of Oregon, I-112; California Farm Bureau Federation, I-183

Suggest that environmental statement should provide greater discussion of the possibilities of fresh water production as an important by-product of the geothermal resource.

Response

The environmental statement is directed to an evaluation of pertinent impacts for the geothermal leasing program. The program represents a short-term commitment for intensive exploration of geothermal resources on Federal lands in the western states. Additional studies, including specific environmental impact statements, would be undertaken for any lease area which shows potential for economic development. It is anticipated that multi-use development of the geothermal resources, including the feasibility of desalting geothermal brine, will be fully evaluated in studies preceding the full-scale operations phase. The potential for supplementing or producing fresh-water supply from geothermal would be dependent upon reservoir engineering, land subsidence controls and local and regional power and water economics. The subject is discussed under the heading, "Full-Scale Operations," in Volume I, Chapter III.

Comment O'Rourke, John T.M., I-406

Hydrological, geological and chemical surveys of the surface and subsurface waters should be made within a 5-mile radius, prior to any groundwater pumping or recharge program.

Response

The final environmental statement has been expanded and revised to more fully discuss regional geohydrologic surveys. Monitoring will be required of various impacts including noise, air quality, water quality, etc. See Volume I, Chapter III.

Comment Lake County Geothermal Control Council, I-367

The prohibition against ground and surface water pollution in Section 3204.1(c)(2) is insufficient, in that it leaves unanswered who tests and inspects and by what procedures and how frequently and what jurisdiction State, county and local agencies have over waste-water storage and disposal on Federal lands.

Comment Lake County Geothermal Control Council, I-653

Cooling water requirements of different geothermal systems should be discussed.

Response

The basic law governing water quality is the Federal Water Pollution Control Act, as amended. Under this Act, the primary responsibility for water-pollution control is assigned to the states. All of the western states, where the principal geothermal development is expected to take place, have such Federally-approved standards. A more thorough discussion of these standards is found in the "Water Resources" section of Volume I, Section III of the general environmental statement. The geothermal regulations require compliance with applicable State water quality laws. By controlling the water quality, potential soil pollution is also controlled. Cooling water requirements also are more fully discussed in the final statement.

Comment State of California, I-81

The waterbalance deficit in Mono Lake is approximately 80,000 acre-feet per year, not 3,000 acre-feet.

Response

Appropriate change made.

Comment State of California, I-81

The major problem of finding a source of make-up water for various reservoirs in Imperial Valley (if large volumes of water are desalinated) has not been included.

Response

The need for reinjection of make-up water to prevent subsidence equivalent to that removed by desalination plants is discussed in the Imperial Valley section of the statement. The source of such make-up water for geothermal



## N. BLOWOUTS

Comment Environmental Protection Agency, I-60

Measures against blowouts must be strictly enforced.

Comment State of California, I-81

Submitted correction to draft statement (Appendix C) on amount spent to control Geysers' blowout (\$300,000, not \$1 million).

Comment Dunn, Franklin, I-285

The draft statement does not consider possibility of release of hot water at unexpected points, due to movement along faults that have been intersected by oblique drilling.

Comment Union Oil Company, I-529

Due credit should be given to the industry for its technological advances to prevent such mishaps (as The Geysers 1957 blowout) from occurring.

Comment Getty Oil Company, I-618

The possibility of blowouts has been overemphasized in the environmental impact statement since it is practically non-existent under modern drilling techniques.

Comment State of California, I-84

The influence is made in the Clear Lake-Geysers section that blowouts are a common inference occurrence, which is totally unfounded.

### Response

Blowouts, or uncontrolled releases of steam or hot water, are of concern throughout geothermal operations. Section 270.40 requires that the lessee or operator take precautions to keep all wells under control at all times. This would include the possibility of release of hot water at unexpected points. Section 270.40 outlines the technical considerations essential for effective preventive and correctional well procedures. These procedures, many of which are derived from the oil and gas industry, include selection of proper types and weights of drilling fluids and the use of proper casing, cement and surface equipment. Pressure relief valves would be required to guard against accidental overpresurization. The installed valves would allow rapid manual shutdown of the unit if failure occurred anywhere in the system. In addition to the control provided through the regulations, specific requirements may be included as lease stipulations or GRO Orders as provided under Sections 270.11 and 270.12 of the operating regulations. The discussion relative to blowouts has been expanded in Volume I, Section III of the final impact statement.

## O. MERCURY AND NOXIOUS GASES

Comment Sierra Club, I-444

The environmental impact statement minimized the problem of odorous emissions.

Comment Environmental Protection Agency, I-64

Environmental impact statement should consider mercury emission problem.

Comment Duke University, I-279

Protests that release of steam underlying Mono Basin would vent into atmosphere significant amounts of pollutants, as H<sub>2</sub>S.

Comment Dunn, Franklin, I-285; Sierra Club, I-459; and University of California, Berkeley, I-538

State the probability that emissions of gases such as water vapor, H<sub>2</sub>S, and mercury vapor would be trapped in the winter inversions over Mono Basin--a point inadequately covered by the environmental impact statement, which should consider possible climate alteration.

Comment Lake County Geothermal Control Council, I-367

Any regional, as well as State and Federal, air-quality standards should be made to apply. Reg. 3204.1(c)(3) should specify that no odorous emissions would be permitted near recreational or residential areas.

Comment State of California, I-81; Pacific Gas and Electric Company, I-410

Suggests liberalizing wording of draft statement to reflect the fact that there is presently no known method of removing H<sub>2</sub>S from steam at the wellhead.

Comment Sierra Club, I-702

Exact standards for air pollution should be set and effective means set for their enforcement.

Comment State of California, I-81

It is felt that the discussion of noncondensable noxious gases in the Clear Lake - Geysers area has not been treated adequately and that this problem merits further consideration.

## Response

The environmental statement has been expanded to address in detail the impact and mitigation of air-quality deterioration from mercury and noxious gases. General provisions for the prevention of air pollution are included in the leasing regulations, Sections 3204.1(c)(3), 3204.1(c)(5) and in the proposed operating regulations, Sections 270.30, 270.40, 270.41 and 270.46. In addition, the various Federal and State regulations dealing with air quality are applicable as well as any lease stipulations or GRO Orders. The concentration of hydrogen sulfide would be periodically monitored. If the gases are not satisfactorily diluted, additional venting would be required. Research is currently under way to evaluate noxious gas removal systems.

See discussion of Air Resources, Volume I, Chapter III in the final environmental statement.

Comment Pacific Gas and Electric Company, I-410

Recommend deletion of methane and selenium from list of toxic substances presented in the draft statement.

## Response

Wording changes have been made in the final statement deleting selenium and listing methane as a noncondensable gas.

Comment Lake County Geothermal Control Council, I-367; Sierra Club, I-702

Some standards for noise level should be adopted and monitoring and enforcement procedures provided beyond inadequate provisions of Reg. 3204.1(c)(5) and 270.42.

Comment Pacific Gas and Electric Company, I-408, I-410.

Noise level standards should apply only at certain locations (specified by Pacific Gas and Electric Company).

Comment O'Rourke, John T., I-406

Suggests that there should be an upper noise limit of 60 decibels at 1,000 feet from the noise source (as BLM required in Mono Lake drilling permit).

Comment Dunn, Franklin, I-285; University of California, Berkeley, I-538.

Believe that noise from the geothermal development in Mono Lake will be excessive and disturbing to local residents.

Comment Center for Law and Social Policy, I-192

Neither the proposed regulations nor the draft statement provides detailed, substantive standards to protect against noise pollution.

Response

Lands involved in possible geothermal development present a wide variety of physical conditions and land use. Therefore, it is most practical to establish standards for objectionable noise for each tract, rather than fix a blanket set of standards for all geothermal development. Such standards will take the form of lease stipulations, or GRO Orders. An expanded discussion of noise and monitoring techniques is included in Volume I, Chapter III of the final statement.

## Q. RADIOLOGICAL AND OTHER HEALTH HAZARDS

Comment Environmental Protection Agency, I-64

The Environmental Impact Statement should consider possible radiological hazards from geothermal fluids and should provide for testing and monitoring for radioactivity.

Response

Analysis of radioactivity of fluid will be required for each well drilled on Federal leases. If analysis indicates a potential health hazard, GRO Orders will be issued requiring special health and safety precautions and periodic monitoring. The recommendations of the National Committee for Radiation Protection (National Bureau of Standards, 1959) as to the maximum permissible concentration of unidentified radionuclides in water will be applicable for continuous exposure. Radon in gaseous form is discussed in the final statement under the heading "Air Resources," Volume I, Chapter III.

Comment Environmental Protection Agency I-64

Provisions should be made to protect personnel from asbestos dust from steam line insulation.

Response

This is discussed in the final statement. Concentration of airborne asbestos fibers in working areas must conform to the standards established in 40 CFR 61, subpart B, "The National Emissions Standards for Asbestos." GRO Orders may be issued, pursuant to Section 270.41 of the operating regulations, requiring more stringent standards for asbestos emissions.

## R. FISH AND WILDLIFE

Comment State of Colorado, I-89; State of Oregon, I-107

Environmental statement must recognize impact of road and transmission line construction.

### Response

The environmental impacts of access roads and transmission lines construction are considered in a number of chapters within the final statement, generally along with other physical impacts of drilling and power-plant and pipeline construction. Specific references may be found within Volume I, Chapter III of the general statement and the individual statements for the three proposed lease areas.

Comment State of Colorado, I-89; Trout Unlimited--Nevada Chapter I-530, I-578

In addition to adhering to existing Federal and State water-quality standards (reg. 3204.1(c)(2), provision should be made to protect fish habitat from thermal pollution and detrimental dissolved solids.

### Response

Leasing regulations, applicable water-quality statutes and their inter-relationships are discussed under "Water Resources, Volume I, Chapter III of the general statement. Hot water discharges are also discussed in this same section. The leasing regulations (Section 3204.1) provide a framework within which lease stipulations and GRO Orders may be developed to avoid, or where complete avoidance is not possible, to minimize to acceptable levels, adverse impacts upon fish and wildlife habitat.

Comment Environmental Protection Agency, I-60, I-64; State of Colorado, I-89; Duke University, I-274; O'Rourke, John T., I-406; Sierra Club, I-436; Simis, Mrs. Jan O., I-465

The environmental statement should present more information on damage to the habitat of aquatic and terrestrial biota.

### Response

Geothermal resource potential exists over much of the western United States, Hawaii and part of Alaska. However, each geothermal installation would involve a relatively small land area so detailed analyses of potential geothermal impacts on biota are possible only when specific development sites have been identified. Thus, regional biotic impact

analyses, such as those found in the final statement, must be general in nature. The final impact statement includes a new section which describes the general environment in terms of major biotic communities (biomes) ecological relationships, geology, land forms, topography, soils, air, water, climate, vegetation, fish and wildlife, land uses, aesthetics and other factors are presented as a background for evaluating environmental impacts (Volume, Chapter II-D). Specific impact analyses for the proposed three lease areas are included in Volume II. Site-sensitive environmental evaluations will have to be made for each proposed lease.

Comment State of California, I-81

The environmental statement overstates impact of reinjection on the Salton Sea biota.

Response

The potential impact of geothermal brine reinjection into the Salton Sea is discussed in the Imperial Valley section of Volume II. The possibility that brines from one well may have a significant effect on the salinity of the Salton Sea is well established. Further, mismanaged reinjection into shallow strata could result in groundwater transport to surface waters and in turn to the Salton Sea with subsequent degradation of aquatic habitat.

Comment State of Oregon, I-107; Washington Environmental Council, I-545; Oregon Environmental Council, I-402; Sierra Club, I-436, I-702

Recommended that officially classified wild and wilderness areas be excluded from the proposed leasing program, along with wildlife or game range areas. Leases should not be issued in recreation areas, near National Wild and Scenic Rivers, National Trail Systems or primitive, roadless or National Pioneer areas.

Response

Section 3201.1-6 of the Geothermal Leasing Regulations describes lands which would be excluded from leasing. Among other exclusions, these would be lands administered by the National Park Service, lands within a national recreation area, fish hatcheries, wildlife refuges, wildlife ranges, game ranges, wildlife management areas, waterfowl production areas, or lands acquired or reserved for the protection and conservation of fish and wildlife which are threatened with extinction.

Lands designated as wild and wilderness areas under the Wilderness Act (P.L. 88-577) would also be excluded from leasing where potential conflict from development would have significant adverse effect on the use of the area. Some possible leasing may take place on Department of Agriculture administered wilderness lands.

## S. AESTHETIC CONSIDERATIONS

### Comment Environmental Protection Agency, I-64

The environmental impact statement should consider clearance of debris, disposal and clean-up operations.

### Comment Sierra Club, I-436, I-459

The environmental impact statement treated scenic impact, and possible solutions, too lightly.

### Comment Duke University, I-279

Geothermal operations pose a severe threat to the tranquility and beauty of the Mono Basin.

### Comment State of Colorado, I-89; Dunn, Franklin, I-285

The impact statement makes no mention of aesthetic liabilities of power plants and transmission lines.

### Comment Lake County Geothermal Control Council, I-367

Management requirements of Reg. 3204.1(e) concerning visual impacts are grossly inadequate.

### Response

While it will not be possible to fully mitigate the impact of industrial development upon aesthetic values, geothermal developers on Federal land will be required to take aesthetics into account during planning, design and construction of facilities (Section 3204.1(f)). All structures, including power transmission facilities and enclosures for generating plants, must be designed to meet existing local architectural standards, to the extent practicable, and should be designed to blend harmoniously with surrounding environment and should have a reasonably artistic and pleasant appearance in accordance with Environmental Criteria for Electrical Transmission Systems (1970). All waste material and debris must be removed under the provisions of Section 3204.1(d) and the lands restored under provisions of Section 3204.1(i). Recent drilling operations from Federal lands adjacent to Mono Lake were maintained in a neat and orderly manner under requirements of a land use permit issued by the Bureau of Land Management. Similar neatness will be required on Federal leases under Section 270.47 of the operating regulations. Additionally, lease stipulations or GRO Orders may be issued requiring additional measures to minimize the impact of geothermal operations on the aesthetic value of an area.

The proposed regulations omit any requirement that facilities to transport steam from wells to powerplants and electric power transmission lines be placed underground. The draft statement, however, fails to adequately explain this omission or to provide a detailed comparison of the costs and benefits of underground and above-ground facilities, sufficient to permit an informed choice between them.

Response

In many situations a requirement that steam and power lines be below ground could be economically infeasible. It also could result in more severe adverse environmental impacts. For example, the disturbance from trenching and underground construction in the naturally unstable terrain at The Geysers could increase sediment yield and might well induce landsliding. Should landsliding occur, the damage and subsequent repair work would be greatly complicated in comparison to that which would be associated with above-grade steam lines. If there should be situations that underground installation would be the only acceptable method, appropriate consideration to such a requirement would be considered at the time development is proposed.

As regards aesthetics, the proposed regulations require merely that lessees "take aesthetics into account" in planning and constructing facilities. Was the alternative of requiring, at a minimum, compliance with applicable State, county and local policies and ordinances considered and, if so, why was it rejected?

Response

The possibility of requiring compliance with State, local and county policy and ordinances regarding aesthetics was considered. However, existing regulations are extremely variable and, in most jurisdictions, no applicable regulations exist for geothermal development. Where State, county and local policies and ordinances are not in conflict with Federal law or regulations, and would serve the public interest, they will be considered for incorporation into the lease as additional terms and conditions.

## T. POSITIVE ASPECTS AND POTENTIAL SIDE BENEFITS

Comment State of Nevada, I-104, I-105; State of Washington, I-127; California Farm Bureau Federation, I-183; Finn, Donald F.X., I-293, I-319

The environmental statement should emphasize the potential side benefits and the positive side of geothermal development.

Comment State of California, I-81

The environmental statement treated the economic and social potential benefit in too cursory fashion.

Comment Oregon Environmental Council, I-686

Statement does not adequately treat economic and social implications of a new power source in an area.

Comment State of California, I-648; State of Nevada, I-580; Imperial County, California, I-634

The draft statement should be expanded to include the possibility of geothermal development providing additional fresh water and minerals through whatever process might be available.

### Response

The statement has been revised to better identify potential benefits. Although most of the environmental statement of necessity discusses possible negative impacts on the environment, it also recognizes that development is proposed because of the benefits to be derived. Additional information on the natural energy situation has been added (Volume I, Chapter II, A.) These benefits include all aspects of life related to power consumption and utilization of any minerals produced. Other potential benefits include increasing the supply of demineralized water for domestic and agricultural uses and improved access to areas for multiple-use development.

Comment Center for Law and Social Policy, I-192

The draft statement lacks a meaningful discussion or attempt to quantify potential benefits of geothermal resources development. Potential benefits are described in terms of uninformative generalities.

### Response

The final statement further discusses potential benefits and the alternatives of geothermal development. Quantification of benefits, like that of costs, is difficult given the present limited state of geothermal development and knowledge. Development of the geothermal resource will provide valuable data to allow for continual increases in quantification and specificity of costs and benefits.

## U. ALTERNATIVES

Comment State of Oregon, I-675

There should be an adequate discussion of energy alternatives and a comparison of their environmental impact with geothermal energy.

Comment Environmental Protection Agency, I-74

Suggests that geothermal power may have more, rather than less impact than alternative sources.

Comment Environmental Protection Agency, I-60

The environmental statement leaves unclear the relative future importance of geothermal steam for power.

Comment Center for Law and Social Policy, I-257

The draft statement contains an insufficient analysis of energy alternatives and their impacts.

Comment State of Alaska, I-76; Center for Law and Social Policy, I-257; Oregon Environmental Council, I-402

Argue for expansion in environmental statement of the section on limiting energy demand.

Comment Oregon Environmental Council, I-686

No attempt is made in the environmental statement to document future energy needs.

Comment Getty Oil Company, I-618

The alternatives to the proposed action are not realistic and should be deleted.

Comment Oregon Environmental Council, I-686

Section on alternatives to proposed action should be expanded to document power needs and compare environmental effects of energy sources.

Comment Environmental Protection Agency, I-64

It remains to be proven whether geothermal resource power generation has the least adverse environmental impact when compared to alternative sources on the basis of no fuel being mined, transported, handled or consumed. The potential of brine contamination of surface waters or subsurface potable ground waters, adverse effects of nuclear stimulation and presence of radon gas in thermal waters, could reverse this position.

### Response

The final environmental statement has been revised and expanded to more fully discuss alternative energy sources. Volume I, Chapter IV, "Alternatives to the Proposed Action," includes discussions of both the environmental impacts and the benefits associated with the various energy alternatives. Development of geothermal resources in a specific geothermal reservoir may pose greater or less environmental risk than the development of alternative energy sources.

The alternative, "Conservation of Energy," has been expanded and reflects recent studies undertaken by the Office of Emergency Preparedness which seeks to identify actions that could reduce energy demand by implementation of various energy conservation measures.

### Comment      State of Oregon, I-120

We disagree with the statement on page 40 that from an environmental viewpoint nuclear plants appear to be the most desirable alternative.

### Response

This section has been deleted from the final statement.

### Comment      Center for Law and Social Policy, I-192

Despite the contention that the prime use of geothermal resources would be for power production, the draft statement fails completely to provide any detailed, factual analysis of power needs and the alleged growth thereof.

### Response

Additional information concerning growing electric power demand in the western states is included in Volume I, Chapter II and in the discussion of energy alternatives, Volume I, Chapter IV of the final environmental statement.

### Comment      Center for Law and Social Policy, I-192

Conspicuously absent from the Department's discussion of alternatives is consideration of postponing full-scale implementation in favor of conducting a carefully planned pilot project designed to provide additional information regarding environmental problems and appropriate methods for controlling them.

### Response

A discussion of pilot plants has been added to the "Alternatives to the Proposed Action" section. Pilot projects are not authorized under the

Geothermal Steam Act or other statutes, so such a project would have to be undertaken under other legal authority. Presumably the cost of such a venture would be borne entirely or in part by the Government, as it could be of nominal interest to private industry. In actual practice, however, because of the high variability in occurrence of geothermal resources, every development necessarily begins at small scale as a type of pilot operation. Both areal and temporal extent of a geothermal prospect are unpredictable, and the prudent investor will undertake development one step at a time, drilling and testing one well after another until sufficient geothermal energy is proved to justify the investment in industrial facilities. An electric power company, for example, normally installs relatively small generating units by stages as further drilling proves up additional reserves. The fact that steam or hot water cannot be transported over long distance dictates such development. Moreover, the unpredictability of the life of the resource dictates against large long-term commitments of funds before careful long-term testing through actual operation. While pilot operations would provide useful information on the technology of development of geothermal resources, it might have little transfer value of other geologic environments owing to the extreme variability of the occurrence of this resource. For example, 70 years of operation at Larderello, Italy, has little transfer value to operations in the United States beyond such mechanical matters as types and design of turbines, means of insulating steam lines, suitable layout of production wells, etc. On matters that relate to environmental impact, such as evaluation of the extent of the resource, chemical character of fluids and gases, susceptibility to subsidence and seismic activity; a pilot operation, say at Imperial Valley, would provide little information beyond what is already known that could be applied, for example, at Mono Lake or The Geysers.

Comment      Center for Law and Social Policy, I-192, I-257

The Department has failed entirely to consider any alternatives to the proposed regulatory scheme by limiting its choice to regulations or not regulations. We submit that it is required to explain the reasons underlying the regulatory approach adopted and to discuss possible alternatives thereto and their relative pros and cons. For example:

The proposed regulations delegate authority to oversee lease operations to the Director, Geological Survey.  
Was any consideration given to establishing a new, independent unit within the Department to carry out this function and, if not, why not?

Response

The final impact statement has been expanded to include a discussion of alternative regulations (Volume I, Chapter IV). The proposed regulatory procedure parallels that employed in other leasable minerals, which over

a long period has proved to be administratively effective and can be carried out at reasonable cost. Consideration was given to establishing a new independent agency to perform this function, but it is felt that administration will be more effective using existing organizational structures and relationships as set forth in Volume I, Chapter I-E.

Comment Center for Law and Social Policy, I-192

The Department concludes that a full-scale geothermal leasing program should be initiated now rather than await further study of its environmental impact and development of missing information. In so doing, it dismisses the alternative of postponing leasing pending further study of environmental impact in five sentences on the ground that "considerable and helpful"--but unspecified--"data and information....is expected to be generated from exploratory drilling activities," which would not be available if leasing did not proceed.

Response

The discussion of alternatives has been expanded to include various leasing options (Volume I, Chapter IV). While the public lands set forth in the regulations will be available for lease application and/or nominations, full-scale development of geothermal resources over wide geographic areas is not expected for some time. The Department is proposing to implement leasing of public land in accordance with the Geothermal Steam Act. The proposed regulations are designed to afford the opportunity for development of the most promising sites in an orderly manner under close supervision. Three areas have been proposed for leasing at this time. As applications or nominations are received for other areas, preleasing procedures as set forth in Section 3200.0-6 of the Regulations will be followed. In this manner, those areas having the greatest resource potential as evidenced by development interest will be identified and priority can be given as appropriate to completion of the necessary evaluations to determine if leasing and development can be accomplished in an environmentally acceptable manner. Full-scale development probably would be limited to those areas where geothermal resources can produce electrical energy at costs equal to, or less than, equivalent blocks of energy from other sources. Postponing the leasing of Federal lands pending further environmental study or the development of new technologies could delay achieving the potential benefits. Adequate environmental protection measures will have to be available or leases will not be approved and development will not be permitted. Initial developments will provide much valuable information relative to the development of geothermal resources in other areas involving similar conditions.

Comment Center for Law and Social Policy, I-192.

A fatal defect in the draft statement is the lack of a thorough assessment of alternatives (a) to the proposed, full-scale geothermal resource

development program, including the alternative of deferring full-scale implementation until a carefully designed pilot project is carried out and evaluated to fill in admitted gaps in important information; (b) to the proposed regulatory framework pursuant to which the program would be implemented; or (c) the specific provisions of the proposed regulations.

#### Response

The final environmental impact statement expands the discussion of alternatives to cover these and additional considerations. The proposed regulation and leasing actions are designed to afford appropriate opportunity for exploration, discovery, and orderly development of geothermal resources. This provides the opportunity to test the potential of federally owned resources with respect to existing or needed technology, economic and social costs and benefits, and potential environmental effects under the wide range of different physical conditions expected to exist. Development will be permitted only if it is in the best public interest and can be accomplished in an environmentally acceptable manner. The proposed regulations provide adequate flexibility and control for management decisions by the Secretary. All areas considered for leasing will be subjected to the preleasing procedures as set forth in Section 3200.0-6 of the regulations. A thorough understanding of potential environmental hazards will be obtained with respect to each leasing area before the determination is made whether or not to permit development of that area.

Comment      Center for Law and Social Policy, I-257.

The Federal actions under consideration pertain to the development of geothermal resources on Federal lands, the relevant comparison for purposes of evaluating the costs and benefits of these actions is between the power potentially available from public lands (and the impact thereon) and the alternatives available for meeting this potential from other sources or for reducing demand by such an amount.

This is not the comparison made in the Supplement. Rather the Department has made assumptions and analyses based upon the total development of geothermal resources--both private and public. This approach unjustifiably enhances the potential benefits of the proposed program and provides a misleading balance between the program and alternatives. It therefore does not comply with NEPA and must be rejected.

#### Response

The discussion of energy alternatives has been expanded to more fully present other known and potential sources of energy. It considers the state of the art in the utilization of these sources and the problems and impacts that could be encountered in the utilization of these energy sources.

The Department has endeavored to estimate optimum development in each of the geothermal areas. This estimate is based upon the amount of information and data available at this time. The Geysers area, at present, is the best known and has an estimated potential of 1,000 megawatts with a possibility of 2,000 megawatts depending upon how far the peripheral area extends.

The Mono Lake-Long Valley area is the least known and only exploration and development will give meaningful information.

Considerable information is presented for the Imperial Valley geothermal area, but this is far short of optimum. It could be that each KGRA might be capable of production in the range of 1,000 to 2,000 MW, but this cannot be better predicted until more is known about the resource.

Comment Center for Law and Social Policy, I-257

The statement does not discuss any combinations of energy source alternatives which could constitute reasonable means for meeting energy demands either in the near-term or the long-term.

#### Response

The energy alternatives section of the final environmental impact statement has been expanded to more adequately present the factors associated with substitution of other energy sources for geothermal resource potentials. However, it must be recognized that a major consideration relative to such options is that it generally is the private sector that develops and produces the Nation's energy supplies. While the Federal Government may have different degrees of involvement relative to individual energy sources or combinations of sources, it generally is not in a position whereby it can direct the nature, extent and timing of such development. Most actions are in the form of incentives; research and development; actions which influence, rather than control, resource development and production. The proposed regulations are being issued in accordance with the provisions of the Geothermal Steam Act (in particular, Section 24, P.L. 91-581). The basic intent of that Act is to authorize the Secretary of the Interior to make disposition of geothermal steam and associated geothermal resources. Section 3 authorizes the making of leases. Economic and environmental factors will be the primary determinants of the extent to which leases are made and geothermal resources are developed.

Comment Center for Law and Social Policy, I-257

The supplement gives an inaccurate and incomplete report of the estimates of geothermal generating capacity made by the National Petroleum Council. The NPC estimated possible geothermal steam generating capacity in the west in 1985 at 7000 MW, based upon a cost of 0.525 cents/kwh. Its estimate of maximum capacity was 19,000 MW (not 20,000 MW as reported in the supplement), which was based upon certain technological developments and increased costs of production which are omitted from the discussion of assumptions in the supplement.

## Response

Possible costs and production rates and quotes from the National Petroleum Council are estimates which are subject to modification as more information becomes available. There are wide variations among estimates. A comparison of recent estimates has been included in Volume I, Chapter II-B.

Comment Center for Law and Social Policy, I-192

What precise "benefits" would flow from the use of geothermal power? What specific power needs are under consideration? When could they realistically be met with geothermal power? What are the alternatives, including efforts to conserve or cut back on power demands?

## Response

The description of potential benefits has been included at appropriate places throughout the final impact statement.

Comment Center for Law and Social Policy, I-257

The discussion of this alternative (synthetic fuels from coal) is unnecessarily vague and cryptic. The supplement states that much of the work in progress in this area is summarized in a 1972 Coal Research Report. The Department should have included either quotations from relevant parts of the report or a summary of its basic findings and significant conclusions.

The supplement admits that coal liquefaction and gasification can provide substantial amounts of synthetic fuels by 1980-1985, but then states that "in view of the critical domestic gas and oil supply situations that are developing the additional supplies so developed may not be available for electric power generation." The basis for this conclusory statement must be set forth in detail and discussed in relation to other energy source alternatives.

The supplement omits entirely any discussion of gasification processes not involving coal. The Department must discuss the alternatives of oil gasification, using refinery feed stocks, as a means of obtaining additional supplies of gas.

## Response

The discussion of "synthetic fuels" must necessarily be general in nature as such operations are still in the laboratory and pilot plant stage. However, discussion of such alternatives has been expanded in the final impact statement. Until these processes become proven, commercial practices and their environmental impacts evaluated, it cannot be assumed that these fuels will be positively available.

Comment Environmental Protection Agency, I-64

The section on refining implies that refining is necessary to desulfurize oil. This is not true. Either high sulfur crudes or residual fuel oils can be desulfurized without complete refining.

Response

Appropriate wording changes have been made.

Comment Environmental Protection Agency, I-64

Suggested wording addition to transportation portion of conterminous on-shore section of the oil alternative.

Response

Suggested wording added.

Comment Environmental Protection Agency, I-64

The section on Increased Domestic Production - Continental Shelf Leasing and Production makes no mention of the extensive marsh areas of Louisiana destroyed by canal dredging for pipeline laying and access to wells and facilities and by subsequent salt water intrusion. Modification of wetlands due to oil development in the coastal areas of the Gulf of Mexico has been extensive, and should be recognized in the statement.

Response

This point has been more adequately covered under the alternative of increased OCS production (Volume I, Chapter IV, 4-b-c3).

Comment Center for Law and Social Policy, I-257

The supplement fails to consider the alternative of increasing domestic oil production through improvements in secondary and tertiary recovery of oil wells. Recovery, which now averages about 30 percent, might be doubled if appropriate measures were taken to cover additional costs. The discussion of the alternative of modifying petroleum market demand prorationing systems also neglected to consider the possibility of improved recovery efficiency.

Response

Discussion has been included in Volume I, Chapter IV, 4-b. The possibility of increasing the overall recovery from producing oil fields has long been considered and gradual progress has been made. However, until the producers can afford the additional cost of such recovery, substantial improvement is not expected. The historic 0.5 percent per year of increased recovery primarily by water-flooding techniques appears to be decreasing.

Comment Center for Law and Social Policy, I-257

A discussion of and the basis for the statement "in view of the critical domestic gas and oil supply situations that are developing, the additional supplies so developed may not be available for electric power generation," is requested.

Response

The relationship of geothermal energy potentials to the critical oil and gas situation has been further developed throughout the final impact statement (Volume I, Chapter II-A, II-B and IV).

Comment Center for Law and Social Policy, I-257

The statement omits any detailed discussion of the alternative of nuclear stimulation of known gas reserves, even though the Department has estimated in its TAPS statement that such an approach might give rise to 1 trillion cubic feet of gas per year beginning in the late 1970's or early 1980's. This alternative must be discussed.

Response

The discussion of nuclear stimulation has been expanded under the natural gas alternative (Volume I, Chapter IV). Nuclear stimulation of known gas reservoirs has potential adverse environmental hazards and, although it may unlock new resources, much research and development effort would be required before such technology could be used. A separate impact statement will have to be prepared if such use were contemplated even on an experimental basis. The results of two completed tests, Gasbuggy and Rulison still are being evaluated. It is impossible to determine at this time if gas produced in this manner can have any significant impact on future domestic gas supplies since the start of commercial development is several years away assuming favorable test results.

Comment Center for Law and Social Policy, I-257

The supplement states at pages 5-6 that "from the environmental standpoint, nuclear power would appear to be the most acceptable alternative to geothermal...." The reasons for rejecting combinations of other alternatives, or natural gas, or reduction in demand as preferable from and environmental standpoint are not discussed in detail nor are the environmental benefits of other alternatives meaningfully compared with geothermal. This lack of detailed comparative analysis of environmental benefits plus the focus on nuclear power as the "preferred" alternative --with its very obvious environmental problems--tends to place undue emphasis on possible relative benefits of geothermal as opposed to other energy alternatives. In other words, the supplement places geothermal in a most favored light, rather than presenting the objective comparative analysis required by NEPA.

## Response

The presentation of alternatives has been expanded to provide a better basis for comparison of options. The acceptability of any alternative is a function of many variables depending on the nature and location of resources, environmental conditions and energy needs of the area involved. Geothermal may be better or worse than other alternatives relative to the specific needs and areas involved.

## Comment Atomic Energy Commission, I-5

The estimates for nuclear power capacity have been revised since the original reference was published and are now 47-61,000 MW by 1975; 139,000 MW by 1980 and 286,000 MW by 1985. The "235" should be deleted from the last sentence of the first paragraph.

## Response

Recommended changes have been made in the final statement.

## Comment Atomic Energy Commission, I-5

The statement concerning effects of open-pit mining seems to be exaggerated since, for example, assuming a 7-foot thickness of ore body, only 800-1,000 acres are required to supply fuel for 10,000 MW for 25 years including initial loading. Therefore, it is not considered acute by comparison with other types of open-pit mining. Also, the ratio of production between underground and open-pit mines is not expected to be maintained but will change considerably over the next several decades. The statement concerning concentrations of radioactive elements being above recommended limits is not representative of the time frame being considered since this situation has not occurred for over 10 years and discharge directly to streams is not planned.

## Response

Comments on the mining and milling of uranium ore may be true; however, disturbance of land surface by mining and disposal of tailings containing radioactive elements do pose potential environmental impacts which must be considered in association with nuclear power developments. Although no information is provided on the change in ratios between surface and underground mining, the possibility of such change has been incorporated into the statement.

## Comment Atomic Energy Commission, I-5

The land included in power plant sites isn't necessarily excluded from other human uses since many utilities are planning multiple-use sites. The last paragraph deals with a current transitory problem and creates an unnecessarily bad image of the ultimate safety of nuclear power plants.

### Response

The statement has been changed to reflect the potential for multiple land-use developments at nuclear power plant sites. Even though the probability of a loss-of-coolant accident occurring is small, as mentioned in the statement, such an accident must be recognized due to the possible long lasting impact upon the environment.

Comment Environmental Protection Agency, I-64

It is stated the "the transportation of spent fuel elements . . . poses a hazard of considerable magnitude." This statement does not appear to be consistent with the text following, which explains that even in event of an accident . . . "no radioactivity will be released into the environment." The final statement should clarify this inconsistency.

### Response

Appropriate wording change has been made in the final statement.

Comment Environmental Protection Agency, I-64

Throughout the section on the nuclear energy alternative, it is noted that the construction and wording of the presentation appears to bias the reader against the nuclear energy alternative.

### Response

This section has been modified in light of comments received.

Comment State of Oregon, I-120

Tonnages of wastes produced by tar sand operations and oil shale recovery are not mentioned nor is the proper handling of these wastes dealt with to any extent.

### Response

Oil shale wastes and disposal are presented in oil shale alternative section of the final statement. Waste production ratios for tar sands also are discussed.

Comment Center for Law and Social Policy, I-257

Inconsistency between 1985 production figure for oil shale and conclusion that this is not a viable alternative to geothermal power under present economic constraints.

## Response

The statement has been modified to reflect that 250,000 barrels to 720,000 barrels of oil are required to replace the projected 7,000 to 20,000 MW level of geothermal power production in 1985. The maximum production of shale oil on both private and government lands by 1985 is 1,000,000 barrels per day. Because of economic constraints, this maximum may not be reached and therefore shale oil cannot be considered a viable alternative to geothermal power during this time frame. At present, there is no commercial shale oil production in the United States.

## Comment

Center for Law and Social Policy, I-257

The general conclusion in the supplement that tar sand development does not constitute a feasible alternative (see page 57) appears inconsistent with the potential resources available in Canada. This apparent inconsistency must be clarified.

## Response

At the estimated level of 7,000 to 20,000 MW of geothermal capacity, the scale of substitute supply from tar sands would be on the order of 1,000,000 barrels per day of production projected to 1985. The National Petroleum Council study on the U.S. Energy Outlook concludes that domestic tar sands are unlikely to have an important role in U.S. energy supply through 1985. Insofar as Canadian tar sands are concerned, the Department cannot second-guess the actions of the Canadian Government regarding expansion or export of production from Canadian tar sands.

## Comment

Center for Law and Social Policy, I-257

The Department's dismissal of hydroelectric as a long-term alternative needs further explanation, including a definition of "long-term."

## Response

In California and most other western states, practically all sites capable of being economically developed for hydroelectric power production have been utilized. Today water storage is primarily for industrial and municipal water supply, not power generation; in other words, power is often a secondary function. Hydroelectric power facilities are long term power alternatives because of the lack of available sites, the environmental problems associated with site location and dam construction, and the long lag time to plan, build, and

install hydroelectric facilities. As described in Volume I, Chapter III, Section G-4-f, of the statement, only about 30,000 MW of additional conventional hydroelectric power and about 70,000 MW of pumped storage capacity is likely to be developed in the United States by 1990 under existing programs.

Comment Center for Law and Social Policy, I-192, I-257

A final illustration of the Department's failure adequately to discuss alternatives is the absence of any discussion of alternatives to the Clear Lake-Geysers, Mono Lake-Long Valley, and Imperial Valley proposals in Appendices C, D, and E. The sections therein entitled "Alternatives" merely refer back the wholly inadequate section on alternatives in the impact statement on the proposed regulations (c-36, D-34, E-36). Although the draft statement asserts that the geothermal resources in these areas will be used primarily for electric power, it does not even mention possible, alternative power sources or compare them with geothermal power, for example, in terms of cost, safety, pollution potential, availability.

Response

A discussion of the alternatives to the proposed lease areas is contained in the program statement in the individual area statements. It is envisioned that geothermal power development of Federally-owned resources in the three proposed areas might be an economically viable supplemental source of electricity. This has been shown to be the case with respect to development on non-Federal lands in The Geysers area. Such development, however, will not replace other forms of electric generation in the sense of precluding the need for steam electric plants, for example. Geothermal development will serve only as a supplement in the sense that in meeting base-load requirements any power generated by geothermal plants will replace a comparable amount of generation of fossil fuel or nuclear plants and could thus represent a saving in fuel and capital investment. Environmental impacts of these alternatives are described under "Energy Alternatives" Volume I, Chapter IV. As electricity is a commodity that is transported over long distances and generated in a variety of ways, it may not be possible to identify specific alternatives to specific geothermal developments and the cost, safety, pollution potential, and availability of specific alternatives must remain largely conjectural. Perhaps an example will serve to illustrate the point.

Example: Assuming that for some reason the present approximate 300 MW generating capacity at The Geysers was denied to Pacific Gas and Electric Company, what would be the alternatives? The immediate effect would be that Pacific Gas and Electric's reserve capacity would decrease by 300 MW and the company would consider steps to replace it. The company might elect to make up the 300 MW deficiency by increasing power generation at existing fossil fuel or nuclear plants through more intensive use of existing facilities, such as by deferring maintenance, by new construction at existing facilities, by construction of new steam facilities of 300 MW capacity elsewhere in northern California, or by purchase of electricity

from other systems. As The Geysers is used for base load (steady as contrasted to peaking power), the substitutable alternative narrows to construction of additional steam-electric capacity, fueled most likely by petroleum or nuclear fuel, at existing plants or at a new location(s). The latter decision would depend upon distribution of loads in the system and on constraints on powerplant siting.

The only assessment of the environmental impact of such alternatives that is possible at this point in time is that somewhere in northern California 300 MW of steam-generating capacity would be required. What type, where, and the environmental impact thereof would be indeterminate until detailed planning was completed. An assessment of the alternatives and their impacts with respect to as yet undeveloped geothermal projects would be even more speculative at this time.

Comment State of Alaska, I-76

One very real alternative which is not really explored in depth in the draft is that of reducing the demand for energy.

Response

The section on conservation of energy has been expanded in the final statement (Volume I, Chapter IV).

Department of the Interior  
Bureau of Land Management  
Bureau of Reclamation  
Geological Survey  
National Park Service  
Office of American and Indian Affairs  
Office of the Secretary  
Office of the Solicitor  
Environmental Protection Agency  
Department of Agriculture  
Forest Service  
Federal Power Commission

The environmental statement work group drew freely upon published literature, State and local agencies, and the expertise of a wide range of professionals, both within the Federal Government and from public, private, and industrial groups, to develop the draft and final environmental impact statements.

Consultations have been held and/or comments solicited from the following Federal agencies with jurisdiction by law or special expertise to comment on the environmental impacts involved in the development of geothermal resources:

Atomic Energy Commission  
Department of Agriculture  
Agricultural Research Service  
Economic Research Service  
Forest Service  
Soil Conservation Service



## VII. CONSULTATION AND COORDINATION IN THE DEVELOPMENT OF THE PROPOSAL AND IN THE PREPARATION OF THE DRAFT ENVIRONMENTAL STATEMENT

The proposed action is a direct result of the passage of the Geothermal Steam Act on December 24, 1970. Under this Act, the Secretary of the Interior may issue leases for the development and utilization of geothermal steam and associated geothermal resources. As the leasing of Federal lands for geothermal development constitutes a major Federal action significantly affecting the quality of the human environment, an environmental impact statement is required under the provisions of the National Environmental Policy Act of 1969.

Two working groups were established in the Department of the Interior to develop leasing, operating, and unit plan regulations and the environmental impact statement. Those participating in the work group preparing the draft and final environmental impact statements and other activities related to the preparation of this document were drawn from the following agencies:

- Department of the Interior
  - Bureau of Land Management
  - Bureau of Mines
  - Bureau of Outdoor Recreation
  - Bureau of Sport Fisheries and Wildlife
  - Bureau of Reclamation
  - Geological Survey
  - National Park Service
  - Office of Hearings and Appeals
  - Office of the Secretary
  - Office of the Solicitor
- Environmental Protection Agency
- Department of Agriculture
  - Forest Service
- Federal Power Commission

The environmental statement work group drew freely upon published literature, State and local agencies, and the expertise of a wide range of professionals, both within the Federal Government and from public, private, and industrial groups, to develop the draft and final environmental impact statements.

Consultations have been held and/or comments solicited from the following Federal agencies with jurisdiction by law or special expertise to comment on the environmental impacts involved in the development of geothermal resources :

- Atomic Energy Commission
- Department of Agriculture
  - Agricultural Research Service
  - Economic Research Service
  - Forest Service
  - Soil Conservation Service

Department of the Army  
     Corps of Engineers  
 Department of Commerce  
     National Oceanic and Atmospheric  
         Administration  
 Department of Health, Education and Welfare  
 Department of the Interior  
     Bureau of Indian Affairs  
     Bureau of Land Management  
     Bureau of Mines  
     Bureau of Outdoor Recreation  
     Bureau of Reclamation  
     Bureau of Sport Fisheries and Wildlife  
     Geological Survey  
     National Park Service  
     Office of Hearings and Appeals  
     Office of Saline Water  
     Office of the Solicitor  
 Environmental Protection Agency  
 Federal Power Commission

Public participation has been solicited in the preparation of the final impact statement through public hearings held at Reno, Nevada (November 9, 1971), Sacramento, California (November 11, 1971), and Portland, Oregon (November 12, 1971). Additionally, written comments have been solicited from the public and other interested parties on the draft environmental impact statement (October 6, 1971-November 23, 1971) and on the supplement to the draft statement (May 3, 1972-June 19, 1972), containing a revised section on alternatives, including a discussion of energy alternatives, and the unit plan regulations.

## VIII. COORDINATION IN THE REVIEW OF THE DRAFT ENVIRONMENTAL STATEMENT

The draft environmental statement, prior to release for formal review and comment, was reviewed informally by the various bureaus of the Department of the Interior. The availability of the draft statement was announced in the Federal Register, Volume 36, Number 194, Page 19447, Wednesday, October 6, 1971, and by a Department of the Interior news release issued Wednesday, October 6, 1971. The availability of the supplement to the draft statement was announced in the Federal Register, Volume 37, Number 86, Page 8956, Wednesday, May 3, 1972, and by a Department of the Interior news release issued Wednesday, May 3, 1972. The announcements indicated the locations where public inspection copies of the draft statement could be obtained as well as the location of sales offices. Written comments were invited for a period of 45 days from the date of notice of publication in the Federal Register; however, all comments received prior to the date of this statement were given consideration in preparing this final statement.

In addition to making the draft statement available for public review and comment, copies were transmitted, with a request for comments, to the following:

- U.S. Atomic Energy Commission
- U.S. Department of Agriculture
- U.S. Department of Commerce
- U.S. Department of Defense (Department of the Army)
- U.S. Department of Health, Education and Welfare
- U.S. Environmental Protection Agency
- Federal Power Commission
- State of Alaska
- State of Arizona
- State of California
- State of Colorado
- State of Hawaii
- State of Idaho
- State of Montana
- State of Nevada
- State of New Mexico
- State of Oregon
- State of Utah
- State of Washington
- State of Wyoming
- Association of Bay Area Governments
- Imperial County Administrator (California)
- Lake County Administrator (California)
- Mendocino County Administrator (California)
- Mono County Administrator (California)
- Sonoma County Administrator (California)
- Sacramento Regional Area Planning Commission (California)
- Southern California Association of Governments
- Washoe County Regional Planning Commission (Nevada)

Comments on the draft environmental impact statement and supplement thereof have been received from the parties or individuals listed in the following index. All written comments and hearing testimony are presented in Volume IV, Appendix I.

Comments fall into three categories: those suggesting changes to the draft or supplemental statement; those suggesting changes to the proposed leasing, operating, and unit plan regulations; and those concurring with, or offering no substantive changes to the regulations or the draft and supplemental statement. Those comments relating to the impact statement have been summarized and responded to in Chapter VI. Comments dealing with the leasing, operating, or unit plan regulations have been combined by regulation number and responded to following the appropriate regulations in Appendices A through F. No response is offered for those comments concurring with, or offering no substantive change to the regulations or the draft and supplemental statements.

The Department of the Interior wishes to thank all parties who have submitted comments on the draft and supplemental impact statement and on the leasing, operating, and unit plan regulations.

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Denver, CO 80225

Form 1279-3  
(June 1984)

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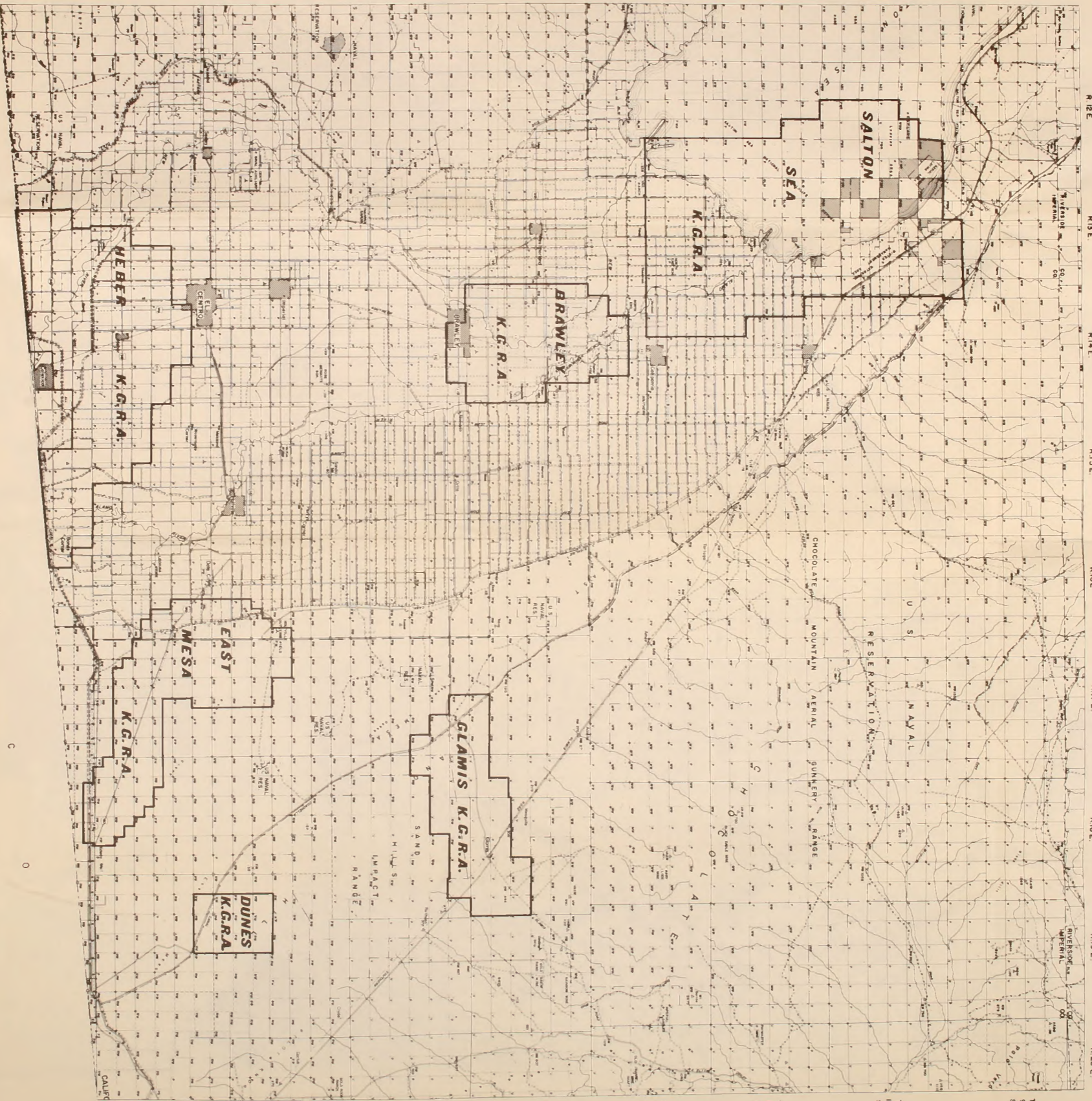
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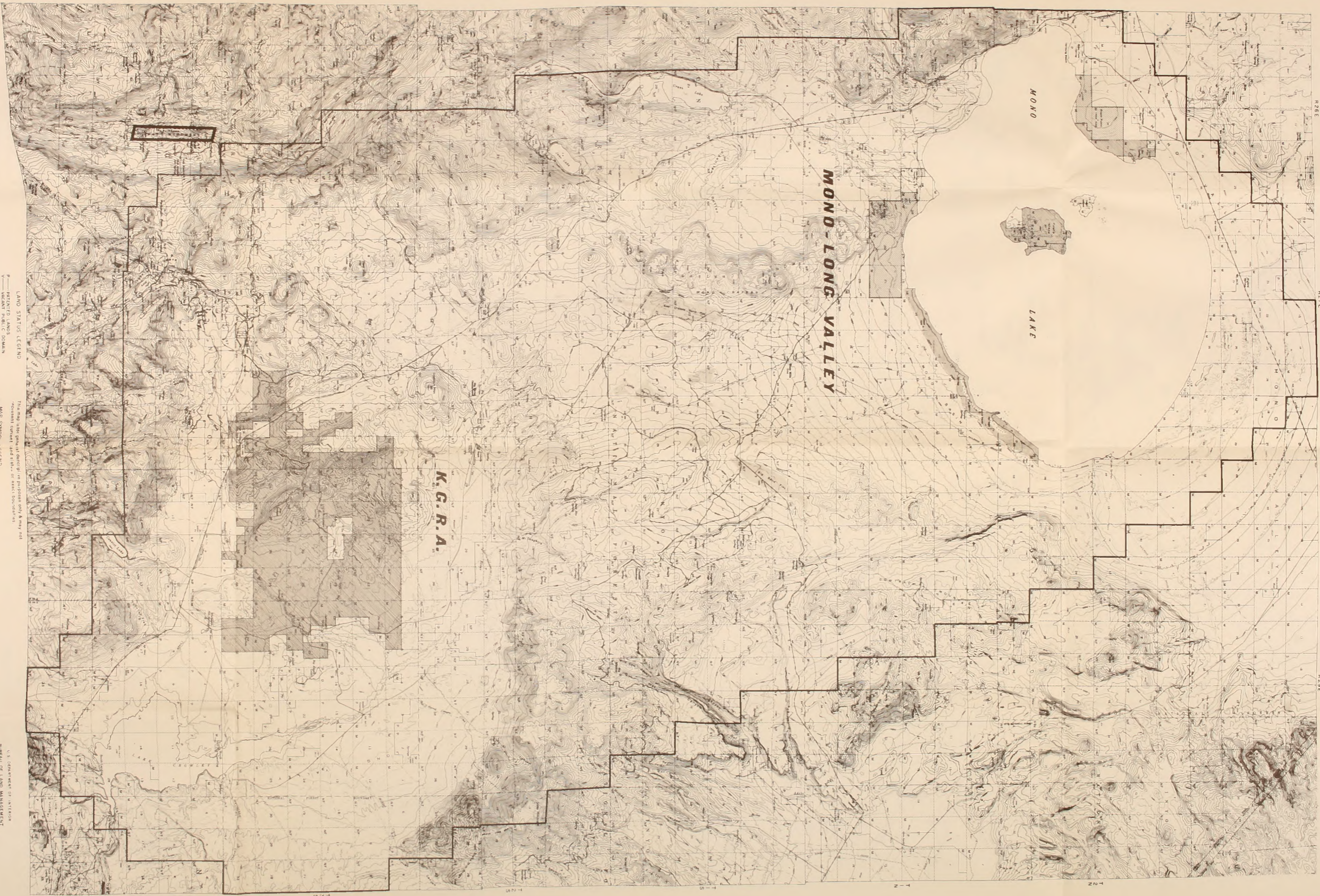


LAND STATUS LEGEND  
P PATENTED LANDS  
V VACANT PUBLIC DOMAIN  
M MINORALS  
B BUREAU OF RECLAMATION  
PS POWER SITES  
AC AGRICULTURAL  
BLM BUREAU OF LAND MANAGEMENT  
PM PUBLIC WATER RESERVE

MAP SYMBOL LEGEND  
URB - URBAN AREAS  
SAV - SAND AREAS

SCALE 1/2" = 1 MILE  
0 1 2 3 4 5 6 7 8 9 10

U.S. DEPARTMENT OF INTERIOR  
BUREAU OF LAND MANAGEMENT  
KNOWN GEOTHERMAL RESOURCE AREAS  
IMPERIAL VALLEY AREA  
This map is for general descriptive purposes only &  
may not represent current land status or exact  
boundaries.



MT. DIABLO MERIDIAN

LAND STATUS LEGEND  
P—PATENTED LANDS  
V—VACANT PUBLIC DOMAIN  
W—WILDFIRE  
N—NATIONAL FOREST  
P—PUBLIC WATER RESERVE  
M—WATER PROTECTION-LOS ANGELES  
G—GRANDPRAIRIE CLASS

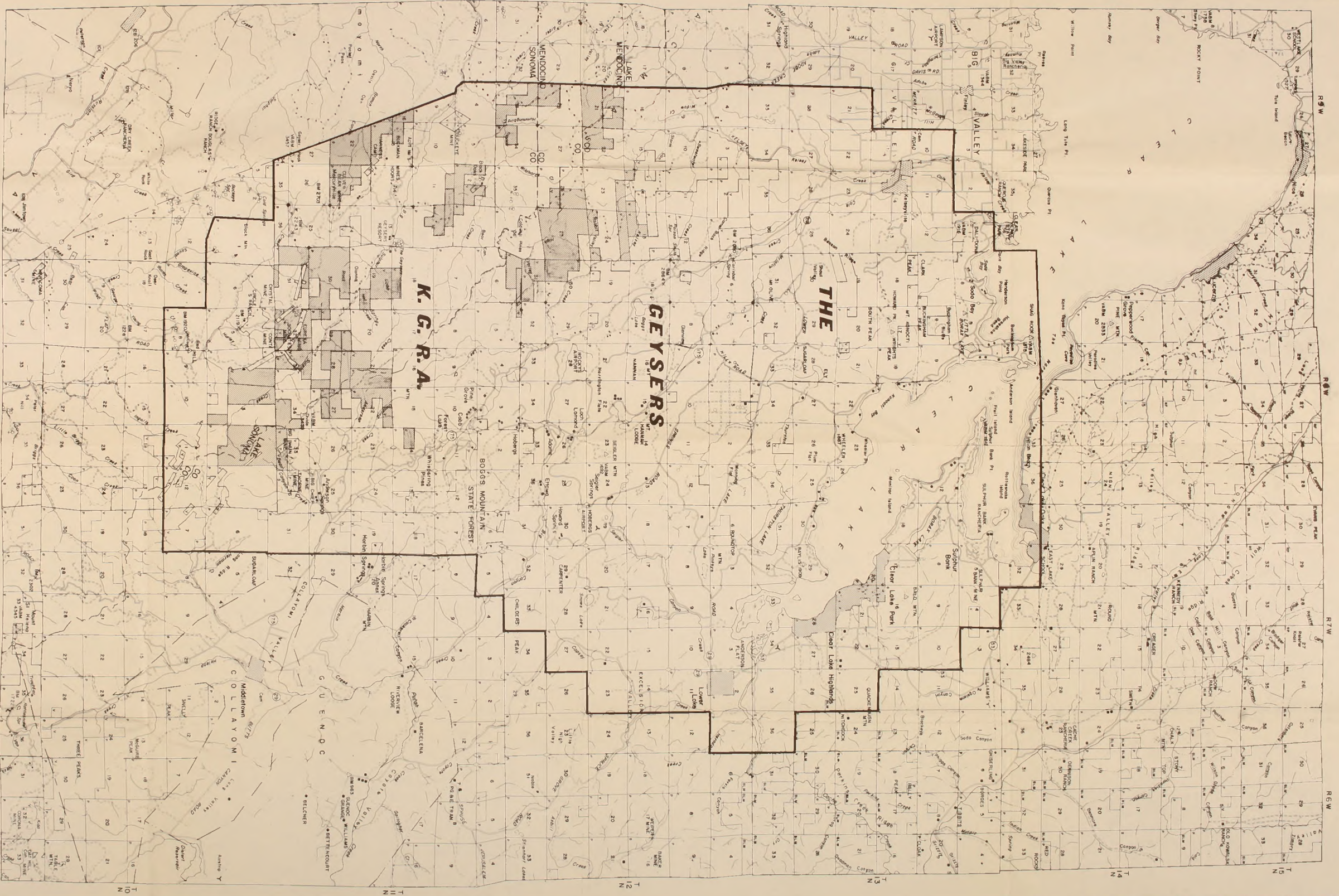
MAP SYMBOL LEGEND  
SAND AREAS

SCALE OF MILES  
0 1 2 3 4 5 6 7 8 9 10

U.S. DEPARTMENT OF INTERIOR  
BUREAU OF LAND MANAGEMENT  
KNOWN GEOTHERMAL RESOURCE AREAS  
MONO-LONG VALLEY AREA

SHADING NUMBER ON OLD 20





LAND STATUS LEGEND

P—PATENTED LANDS

V—VACANT PUBLIC DOMAIN

W—WITHOUSALMS

NF—NATIONAL FOREST

BLM—BUREAU OF LAND MANAGEMENT

MAP SYMBOL LEGEND

URBAN AREAS

MT DIABLO MERIDIAN

SCALE OF MILES

U.S. DEPARTMENT OF INTERIOR

BUREAU OF LAND MANAGEMENT

KNOWN GEOTHERMAL RESOURCE AREAS

CLEAR LAKE-GEYSERS AREA

This map is for general descriptive purposes only & may not represent current land status or exact boundaries.

DRAWING NUMBER 04-050-17

